SCIENCE AND FAITH

HUGH W. SANFORD

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SCIENCE AND FAITH

OR

THE SPIRITUAL SIDE OF SCIENCE

BY

HUGH W. SANFORD

AUTHOR OF

"THE BUSINESS OF LIFE"

14,168

IN TWO VOLUMES

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by
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SCIENCE AND FAITH

VOLUME II

CHAPTER XVI

CRITICISMS OF THE FOUNDATIONS OF MATHEMATICS FOR USE IN PHYSICS

> O, physics, beware of metaphysics!
>
> SIR ISAAC NEWTON

DOES mathematics represent truth within itself, or are its verities limited to the possibilities of structures, forms, and motions in the particles of matter? In translating physics,[1] does our partly abstract mathematics exceed its functions? Is our physics partly metaphysics? These are interesting questions.

Mathematics treats of numerical relations, and numbers at first referred to entities. If there had been no things to be noted, with different quantities to be distinguished, there would never have been numerals. A ''six'' is intelligible as an adjective, just as are the adjectives ''yellow'' or ''hot'', but all are unintelligible unless substantial things exist somewhere to be hot, or yellow, or to be numbered. The personification of the numeral is rational only if it is understood that something real will finally be substituted for the number. Evidently, also, those things which sooner or later must be brought into the mathematical statement must fit into the situation integrally and perfectly, or else the number which has been conceived, or the structure which has been imagined, or the theoretical equation which has been developed, will not be entirely real.

Let us consider simple addition. Each time that three apples have been added to three others the pile has contained six apples. From such experiences we have derived the principle that the addition of the number "three" with three will always produce the number "six." Then, to simplify our mental processes, we assert that abstract "three" plus abstract "three" equal abstract "six"—not only as a general proposition but exactly, and not only as to numerical relations but as to all relationships. First we number objects: Then, after establishing certain relationships of numbers between the numbered groups, we dissociate the numbers from the real things: Then, finally, we assert broadly that this relationship of the numbers (carried over, and abstracted, from the relationship of the things) is true of itself. We thus erroneously accept the equation of an addition as if it were possessed of some reality of its own. Yet to be consistent with the origin of mathematics we should agree that whenever we add three and three to give six, to make the equation really rational and true (of the physical world at least) an absolute equality of mechanical properties must be represented in the halves. And as to the forms, or relations of things in the respective groups, this equality can never be perfect.

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[1] It should be borne in mind throughout this discussion that not the abstract science of mathematics is being criticized, but only the use of such mathematics in translating physical relationships.

The statement that three boys plus three boys equal six boys is of course true in a general sense; but this is an inexact or gross sense. There is more possibility and likelihood of physical error in this syllogism than in the simpler one that the numbers three plus three equal six. When speaking of boys we know that no group of six does exactly equal physically two other groups of three. We do not say that three cats plus three dogs equal six cats,—for we know that the correct addition of abstract numbers alone does not justify the equality for unqualified use,—not even for use in the syllogisms of logic; and we are aware that dogs and cats are not equal physically. Nor do we affirm a final equality between different boys, for in one sense they are different animals. Nor is it correct, when we refer to ultimate values, to state that three dogs plus three cats equal six animals, for this equation is not necessarily true when reversed. The six animals may not be three cats and three dogs. In mathematics, the statement of equality which will be perfectly valid for every mechanical circumstance and usage must have no possibility of being unequal, however the parts are arranged, regarded, or related.

The statement that three groups plus three groups equal six groups is an assertion of an equality in a generalized, or gross sense. By itself it is as meaningless as the equation $3X + 3X = 6X$. The amount of truth (or lack of it) in each case depends upon that which is finally substituted for the generality—for the groups or for the X's. Such equations have no more conclusive mathematical validity of their own —as symbolizing true mechanical relationships, at least— than one composed of pure numbers posing as nouns. In every case the real measure of equality will depend, not upon the numbers, or letters, or general classifications which appear in the equations as symbols for the moment, but upon the nature (the energy-nature) of the things to which these refer.

The lack of validity in physics (and in logic) of a purely abstract number-system becomes readily apparent when we refer to things which are changing rapidly. What three jets of flame can be added in terms of perfect physical equality to three other jets, or what three undulating waves, or darting meteors? The principles of addition would probably never have been formulated had the universe consisted only of flickering and quickly disappearing flames. If, furthermore, all physical things are changing, the numerical formulations true for one moment will be inexact a moment thereafter. We learn, therefore, that a strictly abstract arithmetic is unintelligible; that any truth it does possess depends upon the relationships of the physical facts; and that all of its facts can be only temporarily true.

Some philosophers, however, failing to realize that numbers of themselves are meaningless, have reached incorrect conclusions concerning the validity of mathematics *per se*. Thus David Hume, even in the breath which denied that scientific principles and laws are necessarily valid, insisted that mathematical relationships have an infallible necessity. In the pure or abstract sense, he said, three plus three unfailingly equal six, for the reason that six is at all times contained in the three plus three.

Six what? we ask. Six piles of nothingness? Or, is it just sixes themselves that can be thus measured? Or, if six real things, what six real things? If real things, surely the truth of the equality depends on the attributes and relationships within the groups of things, and not solely upon the numbers used to represent them. If not real things, the statement is unintelligible. And the relations within the groups of three are always different from those in the group of six.

Kant, too, claimed an exceptional status for mathematical laws. He said that they are not only real in themselves, but that they are derived by man's reason as *a priori* concepts. A straight line, he said, has always been the shortest distance between two points, and always will be. Here Kant left abstract mathematics to consider a supposed thing. A line is not a number, though it is sometimes represented by a number; and Kant thus passed from thought of a number by itself as a noun to another principle equally unreal. He first obtained the idea of number as an adjective by applying it to real things that are countable; then he referred to the line as if it, by itself, and separated from its proper number of physical parts, is of necessity a real principle, or fact; and finally, he argued about the straightness of lines as if they were physical realities from end to end. Here Kant reached debatable ground. Before we discuss the idea of a line, however, let us note that the equation of additions may have other inequalities.

When two groupings of three things are associated, they do not exactly equal one grouping of six physically equal things, either with regard to the space-relationships of the things in the separate piles (the structural relationships), or with regard to the characteristics of the groups, and they cannot be treated as if the same in physics. Nor is there an equivalence in the force-relationships internal or external. A man can lift three separate one-hundred pound sacks of flour and place them on a shelf when he cannot possibly lift up the single three-hundred pound sack which stands for their addition. There is, therefore, a lack of physical equivalence in the sides of the equation representing this addition which for the usage under consideration may destroy the supposed equality.

Again, four plus three, and three plus four, both equal seven numerically, but there is a difference in the order of approach to seven. Thus, if a lever were made out of four sections running in weight consecutively from one to four pounds, it would, by any sequence or order, always weigh a total of ten pounds, but if the order of numbers in the summation influenced the design of the lever, and if the largest weight came first so that it would be placed closest to the fulcrum point, the lever would be very much stronger than if this order was reversed. As interpreted physically, there may be a great deal of difference between an arrangement of 1 plus 2, plus 3, plus 4 things, and another arrangement of 4 plus 3, plus 2, plus 1 things. The static and dynamic relationships of parts to one another and to the exterior environment must be considered in the uses of numbers in equations involving more than the idea of mere addition in terms of numbers.

No numerical principle standing alone, therefore, no mere number abstractly viewed, has final reality or meaning in physics. And no formula of a point, line, area, or volume has physical significance when considered as referring to a space empty of matter. All the forms of a mathematics accurately useful in our experiences with the world of matter, therefore, must subscribe to the realities of the relationships of volumes containing substance at rest or in motion. Unless, therefore, the number-values in the equation represent physical attributes exactly, error will enter. Error will enter, too, unless the relationships of parts are properly taken in each equation, and also properly transposed from equation to equation.

Numbers are sometimes employed to measure an absence of the reality of things—things in reverse, so to speak. These minus quantities, as they are called, are not physically real, but they have an indirect significance. I do not refer here to a subtraction in which some one thing is to be taken away from a pile of larger number, but I am thinking of a quantity like minus seven (–7) as a symbol by itself. Minus seven (–7) is real in the indirect sense that, while it represents no physical reality, it stands for a place into which seven positive things (+7) may be inserted. A minus quality is real in the sense that a vacuum is real in physics; but the vacuum would be distinctly unreal, mechanically speaking, unless there were matter under pressure to take note of this emptiness, and which, under appropriate conditions, would tend to occupy it. In a world different from ours, one wherein pressure could exist unaffected by no-pressure alongside, the vacuum would be unreal to mechanics because it would not originate a movement.

In our universe, minus matter represents an absence of usual matter-motion, or energy, and a condition, therefore, which will be followed by a significant movement that will establish a new balance. As conditions are, when seven things under pressure (+7) are brought into relationship with a vacuum large enough to hold them (–7), the two relationships will inevitably merge, and, in the end, there will be a state which we may call zero-pressure. The numerical equation stating that the addition of plus seven with minus seven equals zero, possesses a reality in physics, then, because it is used with regard to a world of balanced energies, to a world in which unequal energies adjacent to one another are invariably merged by movements. The numerical zero as used in dynamics (because the pool of the universe is permeated with energy) represents a condition which exhibits no tendency to movement. Matter fills an energy-void which is just as real as the space-void it occupies. When water is lifted out of a pool an energetic movement is exhibited throughout the water remaining in the pool; and this principle obtains everywhere. A balance in mass-density, therefore, is, in one sense, the equivalent of an energy-balance.

The reality of a symbol representing a certain quantity of minus-matter, depends, therefore, upon the associated presence of something which is real in itself, and to which this lack of the usual energy-condition will act as a negative. The existence of matter (and also of the usual energy-deliveries against material structures) is necessary in order that either a minus quantity or a "zero" should be significant in physics.

Let us now consider the reality of fractions. Since the smallest bit of matter (what ever it may be) cannot be divided, no fractional part of it can be experienced in physics. If, therefore, the number "one" (1) should stand for this smallest bit of matter (as it properly should if we would have the greatest mathematical accuracy), the fractional part of the "one" (1) is unreal. Being non-existent, no physical effect of it could be experienced. When, however, for the sake of convenience, our unit of number, or "one" (1), is used to represent a group of the smallest bits of matter, the fractional part of this group (the part of a generalized "one") becomes real, for it represents integral wholes which do exist and which may be experienced.

One-seventh of a pile of fourteen of the real unit things is a real quantity because it represents, not a fraction of the single unit, but two whole things. The partial or complete reality of a fraction depends, therefore, upon the nature of that which the number "one" (1) is used to represent. The more we generalize our unity, the more we shall require fractions with larger denominators to stand for the smallest quantities experienced in physics, and the more real these small fractions become. This generalized mathematics containing unreal physical quantities in the number-formulas, cannot, therefore, be regarded as an exact statement of fact. Such rough working rules are useful only when referred to large generalizations. One-seventh of the true number "fifteen" (15) finally arrives at one-seventh (1/7) of the true "one" (1), which fractional part is an unreal quantity in physics.

When we consider square roots, cube roots, and roots of higher order, the reasoning takes a slightly different turn. Of course we can cube a number, or raise it to almost any power we please short of infinity, for this process is nothing more than the addition of so many piles of physical things to which the numbers refer. When we cube 4, (that is, 4 things), we are adding together 4×4×4, or 64, things of one kind. Then when the operation is reversed this product will revert to the original number 4. For this reason the cube root of 64 is real. And the fourth root of 4×4×4×4, or of 256, is a real number (4)—and so on. Numerically speaking, therefore, any cube root, or higher power root, which is resolvable into a real whole-number digit, is real itself. If, however, it can never be resolved into whole numbers, it is proved unreal in the sense that it is irrational for use in a physics purporting to be exact, although it may still be a useful symbol for generalization, just as is the concept of the fraction. Yet if numbers are given the proper physical representation, such a thing as the square root of 3 cannot exist, and, therefore, such a number has no reality in an absolutely valid world-physics.

The equilateral triangle, with side of length 2, has a figured area equalling the square root of 3. If, however, what we have just said is true, and if it is impossible to obtain a definite numeration corresponding to the square root of 3, it should mean in terms of our number-system that no physical fact corresponds exactly to the imagined equilateral triangle, and that unit physical things entitled to numbers cannot be arranged to display this physical area. We cannot escape from this conclusion, unless perhaps we may suppose that the unreal number appears because the formula for the triangle is incorrectly calculated in Euclid; or unless perhaps the Euclidean number-system itself does not properly represent the physical facts. At least we can be sure that some physical unreality is latent somewhere—either in the system of measurements, or in the number-system, or in the abstract assumptions.

When we use numbers to represent the length of lines, and then use the concept of these numbers squared to represent areas, and these numbers cubed to represent volumes, we are entering a field in which abstraction and reality are strangely associated. In its strictly mathematico-physical sense, a number squared may signify only a certain amount of adding things together. Yet, for reasons to be given later, the number-parts of a line squared may also be used to represent an area.

Because they have perceived that there is a certain physical validity in the concept that an area may be represented by the square of the number representing a supposedly widthless line, and because a volume may be represented by the cube of the number representing a line, some mathematicians have been led into realms where the abstract idea has no mechanical background. We have no right to think, for instance, that we might raise to the fourth power the number representing a line and thus obtain some structure-or-energy-formation of things which might be experienced in nature yet which is more complex geometrically than a volume. Here the abstract does not conform in any way with the concrete. Indeed, it is merely an accident that our unit of matter is such that multiples of it may be arranged for sighting a comparatively straight direction-line. If the smallest bit had happened to vary sufficiently in weight or shape, or if it had been unsymmetrical within itself, we might never have obtained the concept of a straight-line from rows of it. The attempt, moreover, to use the square of the number of such irregular pieces in a row as a system for deriving the exact physical area within certain boundaries would also have developed many inexactitudes. Our abstract geometry of areas and volumes is fairly usable in practical physics, but this is so because the unit of matter is approximately symmetrical in mass, shape, and even in position and form,—or, at least, it can be averaged to a uniformity when regarded in gross. Unfortunately, however, some scientists carry these abstractions beyond their range of mechanical validity; and then, philosophers, following these tracks, give us incorrect interpretations of the world of matter. The disclosure of some of the unrealities in our mathematics as applied to physics should simultaneously dispose of some of the semi-philosophical and semi-mathematical opinions based thereon. Indeed, much unreality has slipped into our thoughts along with our mathematical concepts. Even Euclid contains its fallacies—weaknesses which are not corrected but augmented by the new transcendental ''four-dimensional'' geometry of the mathematical metaphysician.

In the solid geometry of Euclid, three planes perpendicular each to each, and intersecting at a common point, are taken as surfaces from which to measure the structural forms of matter-bodies. As reason seems to inform us, every point in abstract space can be reached by means of three imaginary direction-lines arranged parallel to these three planes. Hence the Euclidean system of measuring has been adopted because of its convenience. These mutually perpendicular direction-lines do not intersect one another and cause confusion. And as it is impossible to arrange, or even to conceive of, more than three sets of mutually perpendicular and intersecting planes in empty space, the Euclidean system measurement is limited both physically and mentally. Because this artificial system of measuring matter offers us three planes for recording its measurement, it is sometimes called a "three-dimensional" geometry; but, after all, there is only one dimension, for there is only one unit of measurement—one unit of length. Geometry does not become "three-dimensional" merely because three intersecting and perpendicular planes of reference are selected as measuring bases.

A standardized system of measurement was very much needed so that one person could understand what another had computed. When a man has measured his room at a certain place, he probably will—if he wishes to give information to some absent person, or if he wishes to record for the future exactly where and how he measured—find it convenient to use as measurement-references two of the corner lines where the floor of his room intersects adjacent walls. He has measured, however, in only one dimension—that is to say, along only one direction-line, and with only one unit of distance—and his use of more than one line (or plane) as a reference guide does not increase the number of dimensions. The number-notation that he gives the measurement will depend upon the number-system which he selects—upon the unit of length, that is, which he adopts for his "one" (1). Thus the room may be either 10 feet or 120 inches wide.

The three-plane, or solid geometry, of Euclid represents a system of indicating how certain measurements have been taken in three non-conflicting directions. Plane geometry has one plane of reference fewer than solid geometry, and describes areas rather than volumes. With plane geometry one can very well describe the area of a pattern in the carpet on his floor. If the room is a square, the mutually perpendicular corner lines formed by the intersection of the south and east wall with the floor will make typical Euclidean lines of reference. One line will represent the X co-ordinate, and the other the Y co-ordinate from which measurements are taken. When enough dimensions are given which have been taken along lines parallel to these corner lines, one can plot the designated area almost precisely, and determine its location. The more measurements one takes, the more information he can impart. If three mutually perpendicular co-ordinates are used as reference lines (the lines, let us say, of the intersection of the east wall of the square room with the floor, of the south wall intersection with the floor, and the line formed by the intersection of the east and south walls with each other), then, by using dimensions taken along lines which are parallel to all three of these X, Y, and Z co-ordinates, one can describe so exactly the situation and shape of innumerable pieces of a block of wood suspended from the ceiling that another person can approximately determine the space the whole block occupies. Not only this, but one can tell whether the centre of the block is six or seven inches above the plane of the floor. Nevertheless, even though one gives many measurements of a piece of matter so as to convey information about it, he uses only one unit of extension or dimension. No multi-dimensional world exists. It is rather a multi-directional world.

Now, if we propose to measure extensions, and, if we would set down their relative values on paper, we must adopt a unit of length to which our numbers will refer. To be exact, we should adopt that number-system in which the "one" (1) of length corresponds with the extension of the unit of physical matter, whatever it happens to be. Only a numerical summation of this unit of extension, for example, will express in terms of correctly designating numbers the amount of physical matter actually in a line which is composed partly of empty spaces. In practice, we do not use this almost incredibly small unit of length, but an enormous multiple of it. The inch of the ordinary measuring rule is billions of times longer than the extension of the physical bit, and since the units of matter in the average are separated, there is within the inch of extension far more empty space than substance. The ''inch'' of common practice, therefore, is merely a useful generalization, a handy tool for measuring distances enormously greater than the true unit of extension. Such units are convenient when the measurer is not particularly concerned as to how much physical matter, how much real physical extension, the total dimension contains.

Another important principle must be considered. This valid number-unit, this only true ''one'' (1) of matter and of our number-system, must stand for every physical property possessed by this physical bit. Otherwise, the number-system will not always be used correctly in physics. That is to say, the ''one'' (1) of number is equally a ''one'' (1) of mass, of extension, of cross-section, and of volume. When the correct ''one'' (1) is postulated for physics, it should signify that all these properties of the ''one'' (1) (the smallest bit) of matter are present. Not only this, but all these properties must fit appropriately into the mathematical equation. It is important then that we clearly understand what our numbers represent in terms of physical reality when we attempt to use them in translating this reality. When, therefore, the number ''four'' (4) (properly representing four unit things) is raised to the fourth power, this number must signify in physics, not only the numerical quantity of 256, but also 256 units of extension, of cross-sectional area, of volume, of mass. Whatever the arrangement of the 256 things may be there is only this one totality of material fact to exist or to be described.

The simplest arrangement of 256 things is perhaps a row of equally spaced particles lying in one plane. If we wish, however, we may arrange our things still in one plane, but in separate parallel rows of four things in a row, the rows being so grouped as to give sixteen symmetrical (or square) areas each of which contains sixteen things. And yet there are other possibilities: We can arrange the 256 things symmetrically in rows parallel to three mutually perpendicular planes. In this way, we may construct four cubes, each composed of 64 things. Things may be arranged in many ways, but the important principle must be grasped that the summarized total of the physical properties of length, cross-section, volume, and mass, is not in the least altered by the arrangement or by the system of measurement. The properties of matter-structures dictate the terms and conditions to any number-system or measurement-system which is to be applicable to physics. The reverse cannot be true if our definition of matter is correct. The material properties must lead, not follow. Matter is limited, whereas the mind wandering in empty space knows no bounds.

The body with its invisible parts rests or moves before or against us, tantalizing us to determine its innermost secrets, and man naturally adopts that system of computing the physical properties (derived from movement) which seems most suitable. He accepts the challenge of nature. His weapons are experience and reason—but experience has been chiefly valued. The geometry of Euclid was man's first ambitious attempt to derive a dependable and partly mental, partly physical, system of measurement; and Euclid for hundreds of years was regarded as perfect. Men have supposed that its answers were flawless, that its formulas, when properly factored, translated physics exactly. We are beginning to see, however, that its answers are not perfect—that even its factored derivations are only approximate. No mathematical system should be regarded as infallible until the physical facts are positively known, and until one can be sure that the factoring[1] of the scientific formulas gives answers corresponding to these facts—and Euclid does not perfectly meet this test of infallibility. The physical properties exactly defining an object, furthermore, will probably never be "known" exactly through specific experience with matter.

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[1] Factoring is necessary to obtain the physical reality from relationships which are not solid with matter, and which are made up partly of emptiness. Thus if the number "five" (5) is given to a line which contains five bits of matter separated by four open spaces, the actual physical attributes can be obtained only by taking some percentage, or factor, of the generalized "five" (5). We do not realize the necessity of this "factoring" so much when we refer grossly to our composite earth-elements, but we do see the need of percentage-factors to make real our generalized ideas of specific gravities, densities, temperatures, and so on. Factoring is especially necessary when we refer to those attributes which come from force-relationships. Thus the weight of a piece of iron is not the weight of a solid continuum of this external contour, but is the weight which is obtained by "factoring" the theoretical continuum so as to give the action of gravity on the amount of matter that there is. Even the figure for the acceleration of gravity is derived from experience, and is not

Since all mathematics is founded on a number-system, it is particularly important that the properties of the unit "one" (1) of number be properly conceived. The unit of the number-system, if it does not represent the properties of the unit of matter (whatever this unit may be), should at least be factorable so as to represent perfect unity. And yet, a generalized "one" (1) (the "one" (1) of our usual practices) may be factored to give exact determinations of physical nature only if the following conditions can be met: First, for the time in question the units of matter must be arranged in the average so symmetrically and so harmoniously in the multiple formation, that, with reference to the physical experience then being computed, this composite structure will act as if it were a unit of mass solid throughout. Secondly, the theoretical composite formation must be one which may be constructed out of the matter-particles such as they happen to be, and existing subject as they are to the laws of the universal pressure-pool. That is to say, the composite must be a perfect whole-number multiple of the physical unit, and these units must, in the average, be moving in such directions and with such velocities as will maintain the average pressure and exhibit the average structural forms. Thirdly, the edges of time and space must be exactly determinable—that which is impossible for experience. The generalized "one" (1), therefore, can never be factored back to represent the exact unit truth. Regardless of this, however, whenever the generalized formula itself cannot be represented in terms of

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the increase of velocity which we might think would be obtainable from a supposedly continuous force.

We use numbers which are limited in their physical meanings, but if the continuity in mass and force that we sometimes postulate were real, these limited numbers could not represent the facts. We imagine unreal continuity, and then partly save ourselves, as we see, by using discontinuous numbers to describe the situation. This is a strange method. Even then, however, our numbers invariably represent large multiples of the true physical facts, hence in all cases we must use factor-percentages or fractional parts as a means of describing the physical facts even approximately.

rational numbers, an error *must* exist. Thus there are measures of unreality in such fractions as one-third, and in the formulas for the area of the circle and the equilateral triangle, for these properties can be enumerated only in terms of irrational numbers.

We have said that the true numerical unit of length (the ''one'' of length) must be the extension of the smallest bit of matter. If this smallest bit is sphere, the proper ''one'' (1) of length should equal its diameter. A uniform spherical unit provides us with a symmetrical system; for the same unit of length will then represent its diametrical extensions in all directions. It also provides us with a uniform mechanical result for similar unit contacts, for spheres present the same contacting face, however turned. Except for this symmetry of the unit-corpuscle we could not conceive how any formula might be constructed so as to have perfect application, nor how any system of factoring might consistently give exact results. In measuring physical length, therefore, only one unit of measurement is available; and dimensions in all directions are to be taken in terms of it. The so-called second, third, and fourth ''dimensions'' have no physical significance.

We must realize too that the properties and arrangements of the matter-bodies are definitely prescribed. They are given us. Because of the limited numbers of positions, forms, relations, and structures of things, there is a limit to the number of ways of symbolizing correctly, and of conceiving properly, the physical facts. When our abstract mathematics does not correspond with these realities, its application to physics is sure to be inaccurate. The rigidly solid ''thing-in-itself'', with its definite and unchangeable properties, cannot be fitted harmoniously into every imaginable energy-structure. For this reason, the possibilities of real geometrical designs are limited. A new transcendental geometry of the abstract will not originate a new physical truth. Some of its formulas may interpret nature more accurately than the old, but it cannot create reality.

Nature exhibits herself as she is. We cannot see her every detail even on this earth, nor can we look far into the depths of space. On this account, in our attempts to understand her facts, we have properly made use both of imagination and of experience. Mathematical formulations represent one attempt to symbolize nature in laws subscribing to what may reasonably be expected to happen. Unfortunately, however, this science does not treat of the discontinuous world of matter, but was founded when the world was incorrectly supposed to exhibit a continuity of line, area, volume, mass, and even of energy and when only the orderly part of the world was recognized as real. Yet, one has no right to introduce into physics abstract ideas of unreal continuity, and accept them as absolutely valid, unless and until it may be proved by the most particular physical experiences, and also by the most general reasoning, that the formulas as thus founded may be factored to represent exactly the physical facts. This has never yet been done, and cannot be done.

Euclid started with physical experiences incorrectly viewed, and he thus derived a mathematics untrue of the physical world. Then, to make this abstract geometry based upon faulty concepts of lines, points, and planes more useful, its terms were factored to correspond as closely as possible with the results of experience. Even the factored formulas, however, apply to the facts only approximately. They have practical utility, but only for the more generalized cases. And when one refers to some of the modern mathematics of the multi-dimensional worlds, the case is even worse. Conditions are often imagined which are hopelessly unreal of the world of discrete matter-particles. The Relativity hypothesis, however, has a measure of validity, not because it is sound, but because the physical doctrine of Conservation is itself unsound, and requires a factoring modification in some respects similar to that which Relativity adds.

The principle that mechanical action equals reaction (the principle of balance inside that which is unbalanced as a whole) also has an important exception. An Evolution takes place in which the relations of things are altered in a way for which the mechanics of the interior of a balanced pressure-pool does not account. Here the Newtonian formulas break down even within the pool, for a new influence is introduced which is opposed to the perfection of mechanical conservation.

Because matter is sometimes affected by Evolution, the mathematics pertaining to perfectly balanced and pool-like conditions cannot interpret all events. And also because the same processes are never repeated precisely, the idea of Time as the principle within which these changes are accomplished, is, in a far-fetched sense to be sure, not an untrue, concept.[1] Change takes place *within* Time but not by means of Time. Physicists, however, try to cling to Conservation in the midst of phenomena brought about by the ''absolute'' creative forces and ''absolute'' changes which deny it. For this reason they are greatly perplexed; and some of them are led to adopt the mystical theory of Relativity with its implications of a causative time-property, or time-dimension, as they term it.

We shall now leave this subject for more specific considerations so as to see how applicable our generalized mathematics as it has been derived for use in physics may be to the particular, or unit, fact. First let us consider the concept of a line.

What is a straight line? What is any line without material points or particles to compose it? Surely, since there are open places between the corpuscles, the line, after it exceeds the extension of the true unit, or ''one'' (1) of length, is real for us chiefly as a direction—and not as a continuum. It is unreal, therefore, to postulate that a physical line may be represented adequately by a *continuous* number-system. The parts comprising a row of things may be numbered, but if the distance between two points separated by the width of this page is given the number ''eight'' (8), for example, two statements should be made of this system of numbering—namely, that the numeration is a tremendous multiple of the true unity; and that the multiple must be factored before even an approximate physical reality can be drawn from it. That is to say, the number-system involving extensions and lines as now used requires artificial treatment to make it even approximately real. Indeed, it may perhaps be said that of all the mathematical formulations none has been more thoroughly reduced to practicality by factoring than geometry. Until very recently, we had established no factors which all of our every-day experiences of like kind had not seemed to verify. Now, however, that we are beginning to deal with more minute phenomena, we begin to suspect that all the factored formulas are somewhat inaccurate; and that, for the relationships of the minute events, we must develop different numerical units and relationships.

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[1] Yet, as Oswald Spengler says, the ''time'' which is synonymous with destiny or with revolutionary change, cannot be brought [properly] into arithmetic. Space is directly associated with things, and even relative velocities; but time, in so far as it refers to the future happening that may be this way or that, is not an arithmetical function.

Now, obviously, a mentally derived mathematics may be as full of errors in its application to physics as our ordinary concepts (most of them, to be sure, drawn from relatively gross experiences with matter) are erroneous. Thus, if our idea of a line is partly unsound, it will lead us into unreal and misleading mathematical deductions and formulas about lines.

Mathematical deductions, or implications, depend upon our ideas. The mathematical systems are developed from their premises through a series of implications, or deductions, based upon the ideas contained in the premises. In this sense mathematics is virtually a method of arriving at knowledge by making use of formal logic. Starting from postulates, one proposition, because implied to the mind, is deduced (hypothetically) from another. Some of the modern mathematicians even go so far as to think that these propositions of mathematics (even the premises) need have no subject-matter, no real content, but may be valid of themselves—that is, in reference to form only, and without need of material realities as property-givers. They thus believe that symbolic propositions based solely upon their form-connections have a reality of their own, and that, if properly arranged from reasonable deductions, will apply to all possible world-orders. They believe even that the orders of this world may be *discovered* by the use of this method of attaining knowledge—discovered, that is, because of the truth inherent in the method, and not because the method, as it does, has practical value in economizing time and thought.

Professor C. J. Keyser of Columbia University, in *Pastures of Wonder,* a book purporting to define the realm of mathematics, says that when we are "thinking mathematically, we are thinking in a way which, because it is independent of what is peculiar to any kind of subject-matter, is *applicable* to *all* kinds—available, that is, in every field of thought." (p. 41) Now thinking itself may be independent of subject-matter in some instances, though this is doubtful, but certainly the ideas from which deductions are usually made through implications, do not reach our brains and reasoning minds from realms devoid of the properties of matter. On the contrary, ideas seem to be derived normally from relationships with the physical world, and necessarily, if our ideas of these relationships (these mechanical events) are inexact, then the mathematical propositions that we arrange to describe them will be correspondingly inexact. Thus the mathematical proposition used by Professor Keyser (p. 57), "X is a Y", has no meaning if we divorce it of subject-matter. If we mean that there is perfect identity between X and Y as to form alone, as Professor Keyser suggests, then, before we can understand what is meant by "form", we must acquire a mental picture of some composite grouping,—or of some individual entity with inertia and extension,—which because it possesses physical properties (inertia and extension) can express these properties in a form-series, or form-relationship.

There is no significance, for example, in the proposition that one void equals another. Even here we must introduce the idea of extensions, or of the respective sizes of the voids, if the supposed equality is to have meaning. So far as our mental images are concerned, voids may be unequal only in terms of space-relationships, and space-relationships containing no matter are real to our minds (so devoted they are to considerations of the properties of the physical world) only when taken in reference to the positions of real matter-bodies with solidity and inertia that is appreciable. Therefore, unless we introduce subject-matter into such propositions they might as well not be made. And unless we define ''form'' in terms of subject-matter with possibilities of displaying ''form'', it, too, is meaningless as an idea, and without practical value. The statement, X equals Y, is also meaningless when devoid of that subject-matter which regularly give us the sensations from which our ideas are formed, and in terms of which our deductions are made. Indeed, X cannot equal Y in terms of all possible relationships, in fact, unless Y also equals X—that is, unless we mean virtually that X equals X. This last proposition, this statement of perfect identity between subject and predicate, is the only equation-form that is absolutely true in every respect. It, however, is valueless as a source of possible knowledge. It has no meaning to our minds unless the idea which proposed it stuffs it at the same time with some of that subject-matter, the sensation-giving properties of which made the idea possible.

Or, if we refer to another proposition of Professor Keyser, that ''All Y's are Z's'' (which statement is supposed to have the possibility of being true again without reference to any subject-matter), what real meaning has it as it stands? Surely it has none—unless it is found in respect of some one of the possible relationships in which the Y's and Z's (separately, or in their group-formations) are identical in the sense that they are able to give us some type of identical sensations from which the idea of identity springs. The sensation may be that of colour, sound, temperature, hardness, smell, shape, or weight. But, when Professor Keyser speaks of identity in pure form, we cannot understand his meaning unless ideas of the presence of material particles are introduced that might have formations, or ''forms''. We do not conceive how immaterial voids could have ''forms''.

And we note, too, that this proposition cannot be altogether true of all the possible sensations and ideas to be derived from the grouped Y's (and from each of them separately, as well) unless identical sensations and ideas are to be derived from the Z's then in similar relationships. Two different groupings of objects, of course, might give out the same colour-sensation while unequal in their weight-sensations, but if they are not equal with respect of all their possible sensations, they cannot be altogether equal either as individuals or as groupings, and in this respect the proposition setting forth the perfect equality is in error. We conclude, then, that if one is to be entitled to set up the proposition, "All Y's are Z's", there must be complete identity in all the properties of the two classes, and also that the two classes must be composed of individuals with identical properties. Otherwise the Y's cannot be used in place of the Z's in all different situations with equivalent results, and the statement of perfect equality is therefore not justified. If, however, the Y's *are* equal to the Z's in all respects, there is no value in this tautological statement. Indeed, the value of making a proposition seems to come from the fact that it is *not* tautological, that its terms are not identical in all their possible relationships, that the proposition is *not* true in all respects, and that the truth or lack of truth of the affirmed relationship can perhaps be determined by combining the terms in new relationships—that is, in other propositions also in some respects inaccurate.

We combine propositions—that is, we shift the terms of one proposition to another—in an effort to determine the respects in which there is perfect identity in the relationships of the terms of each of the propositions. We test out our assumption of identical relationships between terms by shifting them from one relationship (that is, from one proposition) to another, and we try to determine the truth or myth in the statement of relationship in each of the separate propositions (and in the created proposition) through *experience.*

Thus: Socrates is a man; all men are mortal; therefore Socrates is mortal. The last proposition seems to be a true conclusion; for *experience,* and it alone, here makes us feel that the relationship of terms in each proposition is true. We would not be so sure of the conclusion (because not so sure of the facts) if the argument read: Socrates is a man; all men are six feet high; therefore Socrates is six feet high. To make this last proposition seem reasonably true (because it is really contrary to experience) we should be obliged to make it conditional as to fact—that is, we must introduce an "if" before the first two propositions. But, when this is done, the conclusion is of no particular value. Even in the first case, the conclusion is of no particular value. It represents merely the setting-forth of a new relationship. It is true or false to our minds according to the certainty, or lack of it, that we ascribe to the relationship of Socrates with the genus "man", and to the relationship of mankind with mortality. If we have any certainty that these relationships are universally valid the knowledge does not come from the forms of logic, but from life-experiences. And this validity of statement, or lack of it, refers to the subject-matter symbolized in the terms, and to nothing else. And we note that whereas all men may be mortal, all mortality does not refer to men. Hence the terms are not identical in all of their relationships, but the equality stands apparently for the particular relationship in which we happen to be interested. Yet, by throwing part of the relationship of terms as assumed to be true into a new environment, we can establish a new relationship of terms which may or may not be true, but which, if true, may be valuable.

Let us consider the following three propositions: 2 plus 2 equals 4; 7 plus X equals Y; therefore 7 plus X plus 2 plus 2 equals 4 plus Y. In mathematics the concluding proposition is supposed to be proved, yet, as we have already observed, the first proposition, if it is given subject-matter, is not *perfectly* true,—that is, it is not necessarily true as to subject-matter in the new relationship. No, even in the use of pure numbers there is a decided difference of content between the two halves of the proposition stating that 2 plus 2 equals 4.

Except for the fact that the shifting of terms between propositions may reach relationships approximately valid (and also new) the processes of logic would be useless. The only proposition true in every particular is the statement setting forth the complete identity of subject with predicate; and the use of this proposition affords no new knowledge. The assurance of the validity of a logical process by which new propositions are obtained as new combinations of the halves of old ones, is derived not from the logical process itself, therefore, but from the conviction reached by the judgments of experiences that the statements of relationships in the first propositions are broadly true,—at least to the degree that the meanings of the transposed terms are such that they can safely bear transposition into the new relationships.

Indeed, as we view it, the use of mathematical propositions, with its exchange of symbolic terms from one equation (proposition) to another, is valuable, not so much because it affords new combinations of terms which may or may not be true, but because it affords in many cases a short-cut method of calculating. The new relationship may fit in with the subject-matter of some physical situation so exactly that it may be useful as an approximate method of formulating the situation in its general outlines. The symbolic proposition X^2 plus Y^2 equals R^2, is thus a useful but inaccurate proposition purporting to represent the points imagined to be continuously on the circumference of a circle. When this proposition is factored sufficiently it becomes more useful, because more exact; but we wish to emphasize the point that we would never have acquired the utility of this approximate formula had we not transposed terms from one proposition to another in the way that is done in mathematics and logic. Nor would the formulation have practical value except for the fact that part of the universal happenings—those, at least which we "sense"—are "orderly". When we average an orderly composite event (one generalized in space and time), if the order itself does not change rapidly we can count on duplications of the mechanical events under corresponding mechanical conditions. But we do not arrive at a new truth in this way, but merely at a new relationship, or method of formulating. Moreover, this method, more than likely, will lead to answers partly untrue.

We repeat that if the proposition, "All Y's are Z's", is to be more than a tautology, if it is to be valuable for reaching a new set of relationships in another proposition, the terms must even be unequal in some of their relationships—that is, the equation must be partly untrue. Although we may think we have avoided all idea of content in our terms, we find that we have not (and we should not wish to do so), because there is neither meaning nor utility in making the statement that two volumes of nothingness are equal. Indeed, the Z's and Y's are different even as symbols because they have a certain content-difference. They are different to vision, they are different line-formations, and as letters to be pronounced they consume different amounts of energy of the voice. If they had no differences, the statement becomes: All Z's are Z's. And what significance do we indirectly attribute here to the "all"? Obviously, we imply a class, or grouping, or composite with discrete parts subject to numeration. And even the verb "are" has deep life-experience-subject-matter. There would be no need of logic, deductions, or implications if there was a complete identity between the terms of a proposition in all their possible but entirely empty relationships and aspects.

How, then, can one suppose that symbols may possess utility as terms of propositions and still be empty of everything except undefined "form"?

Let us consider specifically how a proposition may have more than one set of meanings and relationships, and how the truth or untruth of the relationship can be discovered by placing one of the terms in a new relationship. The statement "the eggs in this basket are fresh", may be true as to average contents, but if the different eggs are separately tested, an error (a myth, Professor Keyser calls it) may be disclosed. The changed relationship, the testing of one egg out of the hundred, proves that a certain one is stale, whereas, in the group-relationship,—that is, when all the eggs are considered together,—the fact that one egg is stale could not be detected. Indeed, a physical mixture of all the eggs would still be properly termed "fresh". The property of a single individual of a class may be different from the property of the class, therefore, and the class as a whole will likely give a different average property-sensation from that afforded by the particular. We thus realize one value that may come from the transposition of terms from one proposition to another. The proposition "the eggs are fresh", moreover, as all propositions, has several types of relationships and possible meanings. It may mean that every egg is fresh; but it may equally well mean that the class as a whole, when averaged, displays the property of freshness. By throwing the terms into new relationships we may perhaps arrive at a new interpretation of the truth.

In some respects the Y's may be Z's, and in some respects not. They are not the same letters. If, however, as Professor Keyser states, neither the individual Y or Z, nor the groupings of Y's or Z's, has subject-matter content, and if there is no possibility that there might be variations in the relationships of contents by transposing the terms into different propositions, we might as well leave the proposition alone. No sort of manipulation of it will disclose new truths—the truths, as all truths of the life of sensations are, of new relationships.

So much for the utility of mathematical processes. We cannot consider the subject further here. We merely assert that if the idea of the truth of a mathematical (hypothetical) conclusion is indeed partly mythical, the amount of myth may be determined only by recourse to different types of experience, or to definitions reached by a separate process of general reasoning. The specific experience of one relationship—as may be set up in one proposition, containing subject-matter-contents—never reveals the exact truth. We cannot derive certain knowledge directly from, or through the use of, a completely symbolic mathematical deduction. The value of symbolic mathematics is derived chiefly from the fact that it is a tool developed by the mind, which, with its premises founded on experiences with certain fairly orderly (when generalized in space and time) subject-matter, usually affords a short-cut means of transposing (or of interpreting) values in reference to these particular types of experiences as later repeated under almost identical conditions. If, however, its use has been based upon inexact concepts, as is almost invariably the case, or if the situation is not orderly and subject to uniform averaging, its conclusions will be inexact. And because geometry, trigonometry, analytical geometry, and the calculus are based upon ideas partly inexact, they are all now somewhat misleading—and because they are based on generalizations, they do not refer to the unit event —that which affords the philosophic background of a true understanding of life and its experienced processes.

The classic, or Greek idea of mathematics, referred solely to things *perceptible to the senses.* Yet nothing *is* completely or exactly perceptible to the senses. We can, however, realize things that cannot be "sensed" directly. Electrons one at a time are invisible, but they subscribe in multiple to properties (that is, to the properties of group-formations) which may be formulated as part of an expected and sensed routine as a whole. The mathematical formulations of this routine will then be fairly accurate, but only provided that the formulas have been accurately composed with a number-system properly chosen and arranged. Experiences with things help us—even permit us—to arrange our mathematical propositions with some accuracy, but because these experiences are always somewhat vague and hazy, the "appearance" must always be interpreted (and the proposition relating to it corrected, if possible) by means of a reasoning referring to general events. Only thus may our principles be made to apply, not only to the grossly seen, but more exactly to the more minute unseen. The unseen, as we know, when grouped, delivers a visible effect, and so we must reason from the experiences with the properties of the grouping, or class, back to the necessary nature of the invisible unit of the groups, and also to its necessary relationships with the other units of the group. Through this sort of reasoning we may realize the errors contained in our present-day generalized and factored mathematical propositions.

Dynamics, too, or the delivery of motion from one piece of matter to another, must be interpreted partly by general reasoning. If the formulation of the energies of moving bodies is to be correct, the separateness of the particles causing the energy-delivery must be postulated. We cannot reach the fact of discontinuity by factoring an imaginary continuum. A mathematical proposition based incorrectly upon the idea of continuous subject-matter is not true, however it may be factored.

Yet Professor Keyser says: "No mathematical proposition has been, is, or will be, contradicted or invalidated, by any true proposition regarding any subject-matter that has been or is or can be.'' (p. 99) Certainly this is a positive statement. It immediately follows a sentence using an ''if'' implying that mathematical propositions are not necessarily true, namely: ''Mathematical propositions, if true, are eternal verities.'' This sentence has a pleasing rhythm, but it really means no more than that ''Truth, if true, is truth''. The difficulty arises in determining when we have reached the true. Professor Keyser is wrong, we believe, in insisting that any mathematical proposition which is true *of itself,* —that is, as he puts it, true of a world without subject-matter —is equally true of a world containing subject-matter possessing certain definite properties. In fact, the mathematical propositions which have been developed to symbolize the supposedly continual gravitational forces and other continuities are now being proved inaccurate for use in reference to our world of discontinuous matter and energy. The attempt to factor a supposed continuum so as to represent the fact of discontinuity, leads inevitably to error. General reasoning is necessary to point out the percentage of error that these formulas contain—a percentage constantly larger, we find, as the more particular experience is approached.

Following Diophantus, then, we may make use of abstract symbols as substitutes for numbers—or things numbered—without necessarily getting into grave difficulties. When, however, we follow Descartes, and treat of an abstract or ideal uniformity, rather than of a space containing certain definite matter-relationships, certain limited extensions, and certain gaps of nothingness, the truth is not attained. We have no right to postulate a completely symmetrical relationship which does not exist. Yet with the use of the corrective constant, these broad generalized formulas may be made very useful. Fairly accurate answers may be quickly obtained from these basical formulations founded on unreal assumptions.

As Professor Joseph A. Leighton writes in *Man and the Cosmos,* in pointing out the unreality of the mathematical concept of continuous space and time: ''A conceived realm of pure positions and directions, of positions occupied by nothing and of directions in which nothing moves but pure movement, is of course logically continuous and boundless to any extent one pleases. . . . But such a space and time exists only in the mind of him who thinks them. They are as absolute as one pleases because there are no inconvenient facts to mar their completeness. An infinite continuous order of dimensionless points has nothing to do with actual space.'' (p. 222) And: ''It is possible to continue the process of abstract construction to the point of developing space theories from which the qualities of empirical space have vanished. Indeed these things are being done.'' (p. 122) And then, referring to Einstein's idea of space he writes:

''I am unable to attach any definite meaning to a non-uniform space. Space as a whole cannot bend; a curved space is a contour or spatial relation of something spatial that is, material, not of space itself.'' (p. 223 foot-note) Finally he says: ''But to identify space [*per se*] with mass or force would be to deprive ourselves of any means of relating masses.'' (p. 227)

Unreal numbers, even infinities and zeros, are helpful in some of our problems. Indeed, many of these symbolic short-cuts approach reality so closely that the use of them has convinced some persons that there is an abstractly mystical and almost non-material basis for mathematics itself. As we have observed, some still assert the validity of the abstract science of mathematics apart from the qualities and relationships of the things to which its symbols refer. We have thus been led to use these incorrect mathematical assumptions as if they were proofs of some incredible hypothesis about the physical world—such, for example, as the modern attempt to account for atomic phenomena on the assumption that electrons exist only periodically, and may appear spontaneously in different places without having been anywhere or done anything since their last physical appearance. We have stipulated imaginary conditions, have arranged imaginary formulations to describe them, and then have used these mental fabrications to prove that unreal principles are true of the physical world.

M. Bergson recognized the possibility of error in the "intellectual spatialisation" of things. Professor A. N. Whitehead endeavours, however, to show "that this spatialisation is the expression of more concrete facts under the guise of very abstract logical conclusions." "There is an error," he says, "but it is merely the accidental error of mistaking the abstract for the concrete. It is an example of what I will call the 'Fallacy of Misplaced Concreteness'. This fallacy is the occasion of great confusion in philosophy. It is not necessary for the intellect to fall into the trap, though in this example there has been a very general tendency to do so."[1]

As Professor Whitehead remarks, Pythagoras asked one of the most important philosophical questions thus: "What is the status of mathematical entities, such as numbers for example, in the realm of things? The number 'two', for example, is in some sense exempt from the flux of time and the necessity of position in space. Yet it is involved in the real world."[2] And Professor Whitehead goes on to point out that "in the procedure of relating mathematical notions to the facts of nature, by counting, by measurement, and by geometrical relations, and by types of order, the rational contemplation is lifted from the incomplete abstractions involved in definite species and genera, to the complete abstractions of mathematics."[3]

I am objecting somewhat to this process, not because it does not possess practical value, but because too much untruth is concealed in the mathematical abstractions. That is to say, its conclusions do not refer exactly to the shapes, forms, numbers, and possible orders and relations in this world as now constituted. For example, just as a series of particles cannot constitute a continuous line, so also there is no infinite number of physical directions, for direction-lines which do not pass through rows of particles are meaningless for a valid physics. Let us consider also the theoretical curve.

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[1] A. N. Whitehead: *Science and the Modern World*, pp. 74–5.

[2] *Ibid.*, p. 41.

[3] *Ibid.*, p. 43.

Points, or intermittent corpuscles, may be arranged to constitute a many-sided polygon, but not a continuous curve. For this reason, there can be no continuity of curve in the material relationships. Even the perimeter of the polygon is unreal except when viewed as the figure formed by the imaginary intersections of a series of direction-lines running from the centre of a particle to the one adjacent, and thus associating them. When such direction-lines are imagined, however, we obtain the idea of an enclosed area, which, as a space-relationship, is real, and which, for any certain element, will contain a certain number of corpuscles. But since we cannot sight from one point to the next except by the aid of the approximately straight path of a ray of light, we cannot look from one corner of our physical polygon to the other on curves. Furthermore, if we tried to imagine some bending line connecting one corpuscle with the one immediately beyond it, we should discover that, whereas there would be millions of these imaginary curves running through the two points, only one of them, when continued, would pass through the next corpuscle beyond. If one wished to fabricate the ideal curve that would continue to be deflected sufficiently to pass through the various points, as already symmetrically arranged, there would be no way of doing so except by the trial and error method. This, however, would be impracticable. It can be done only approximately, even on the drawing-board.

And, finally, the nature of the abstract curve that might be supposed to pass through a series of particles would depend entirely upon their arrangement. If corpuscles were uniformly spaced, in the average, like the dots on a necktie, for example, no circle or ellipse could be imagined that would pass through the six of them closest together. The reasonble alternative for the imaginary curve for associating contiguous points is the straight path of the light-ray. The series of paths of the light-rays connecting neighboring points that are symmetrically disposed, will give a symmetrical polygon with approximately straight-line sides of a certain average length. These sides correspond not only to the fact of vision, and are true, therefore, of a static geometry, but such a figure corresponds also to a dynamic condition, for every mass, when moving free from influences, will (according to Newtonian axioms) trace out the same straight-line path that the light-rays themselves follow when uninfluenced.

If, however, there is no static or dynamic physical curve, when we imagine one either as a geometrical figure composed of composite bodies or as a path created by forces acting upon a moving body, we are glorifying a mental fabrication, and are falsely postulating a condition which *might* relate to a world of pure emptiness, or to a uniform continuity of matter or force, but which *does not* refer to the universe of inert corpuscles spaced as they are and moving as they do. To use Professor Whitehead's phrase, the mental abstraction which ends in the idea of a physical curve is a "Fallacy of Misplaced Concreteness."

If the smallest corpuscle is a sphere, the smallest hexagon in nature will be composed of a solid figure made of six spheres closely surrounding a seventh (see Fig. 1). Yet we cannot assert positively that such a figure will ever be found. If we suppose that it may be constructed, then, when the diameter of a single corpuscle is taken as the unit of distance, or as "one" (1), the hexagon formed by the direction-lines running from centre to centre of the surrounding corpuscles will be the figure which the light rays in the average might trace. The abstract geometry postulates, however, that there may be a continuous circle of matter with a diameter of 2 units—that is, with its radius equal to the diameter of one single corpuscle. This unreal circle is supposed to have a physical circumference equalling approximately 2 x 3.1415 (plus), or 6.28 (plus) units of length, whereas the length of the perimeter connecting the centres of the

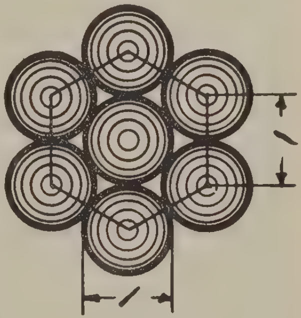

Fig. 1

six corpuscles in straight lines is exactly six times the diameter of a corpuscle, or 6. Nor could any circular path of this circumference be physically real throughout in the sense that its perimeter would remain entirely within the matter of the six corpuscles. The perimeter of the hexagon with sides of length "one" (1) alone displays this reality.

Only when an enormously greater polygon is considered, one that would include billions of corpuscles; only when the diameter of the single corpuscle, or the true "one" (1), is taken as a smaller and smaller ratio of the total perimeter—that is to say, only when the unit of number, or "one" (1), is applied as a gross generality to a distance enormously greater than the diameter of the smallest corpuscle—will the physical perimeter of the symmetrical polygon with sides "one" (1) approach closely the length of the abstract generalization known as the circumference of the circle of radius "one" (1). Indeed, the perimeter will never quite reach this abstract curve until an infinity of corpuscles is brought into the picture—that is to say, until this broadest of all unreal generalizations has confused the reasoning and falsified the concepts of physics. Under the shadow of infinity almost any house can be built; but in the relations of the universe of finite and discontinuous matter, the formula for a physical circle with diameter greater than "one" is inaccurate. Nevertheless, the abstract concept of a perfect circle of large dimensions has usefulness, for our usual experience does treat with enormous numbers of the unit corpuscles, and in all such cases the percentage of error that comes from the use of the abstract formula is very slight. Our usual physical "one" is not the true or unit "one" (1), but comprises countless trillions of units and this fact makes our generalization fairly appropriate.

We realize, too, that just as material particles do not touch one another continuously, so also there is no continuous delivery of momentum. Since undisturbed bodies appear to move in straight lines, since every new motion is transferred by one moving unit and solid body to another instantly on contact, and since all motions are created, we believe, through contacts, the paths created by the intermittent blows of matter-bodies cannot follow a continuous curve. We conclude, rather, that the paths of all corpuscles are abruptly changed by blows from time to time to a new direction of straight-line motion.

When a mathematics postulates a continuous curve, therefore,—whether it be a line traced on the drawing-board with a pair of dividers; whether it be the imaginary line connecting up the centres of motionless particles; whether it be the paths of the planets; or whether it be thought of as the cross-section of some body (provided the body is larger than the indivisible unit-corpuscle),—it is (so far as physics is concerned) an unreal abstraction. In every case it will prove to be only approximately true as a generality; and the supposed curve, when subjected to more microscopic examination, will break up into straight-line parts.

Mathematics is inexact likewise when it postulates numbers without end for any part of the physical universe we choose to consider. This unreal mathematics of the continuum, however, may be helpful. Indeed, when the formulation refers to such a tremendous number of corpuscles that the error (after factoring) in assuming a solid continuity of parts each infinitesimally small (for the sake of making use of a symmetrical formula, such as that of the circle, for example) is perhaps only a trillionth of one per cent., we may feel justified in using the incorrect method. This practicality, however, does not prevent the principle from being unsound—as well as dangerously misleading. We are apt to be deceived by the proved near-accuracy of the result, and are apt to make the great mistake philosophically of using this false generalization to interpret some other concrete fact to which it should not be applied. This leads us into a fundamental misunderstanding.

Let us suppose, for example, that ten million separate masses strike a solid wall every second, each with the momentum of a foot-pound. Between the blows no force is delivered, but we cannot possibly appreciate or realize these tiny time-intervals of only one ten-millionth of a second. As a matter of practice, therefore, we make use of a generality. We assume that ten million foot-pounds of energy are being delivered *continuously* throughout each second. Certainly experience cannot disprove this statement, and the assumption is simple. When an event is composed of such tiny parts that we cannot realize them separately, we naturally generalize in terms of that longer time-interval which we can experience. We thus average the periods of events and non-events. In the preceding example, we take the elapsed time of one second, which includes the misty beginning and end of ten million separate tiny events, and we average the force-delivery for this comparatively long period. Our generalized statement is almost a true summarization of the total happenings during this relatively long period of time.

Yet, in reality, what have we done? We have disregarded, or at least have jumped over, ten millions of actual durations within the second during which no force *is* being delivered, and we have used a formula which assumes that force-delivery has been an unremitting succession of almost infinitesimal units of force from beginning to end of the second, when it has really consisted of a definite number of measurable momenta at definite times. We may be justified in using this erroneous and generalized formula as a convenient approximation of the composite result through multiple units of space and time; but we are not justified in using it as a guide to exact knowledge. We must not permit its practicality to lead us into a misunderstanding. We must not forget the method by which we included the real and the unreal in a broad summarization; and we must not go so far as to state dogmatically that here is an illustration of a continuous flow of force from end to end of the second.

Yet who cannot hear the argument of the practical man? It will run like this: "The formula postulates continuous force against the wall of ten million foot-pounds a second, and the formula proves to be accurate in experience; therefore, the conditions which it postulates are thereby proved true."

Only he who knows the real conditions, or who can arrange an instrument delicate enough to disclose the particular event, or who makes use of philosophy to indicate the unreasonableness of the idea of a continuous while limited force, can disprove that which practice here seems to indicate. And philosophy has little weight when it seems to be in conflict with the findings of the empiricist.

Many have thus made the error of assuming that gravitational force is continuous, and that continuously curved paths are caused by its unremitting deflection of motions otherwise straight. What man's logic will be accepted as proof to the contrary; and yet who can prove otherwise with instruments? What measuring devices are sufficiently delicate to separate events which follow one another at intervals of an almost infinitesimal part of a second? Must not the philosopher, then, leave the physicist in possession of his cherished belief?

He must not! He should refuse such surrender to fallacy.

To the philosopher, a continuously delivered force is inevitably an infinite force—something which gravitation is far from being. The philosopher, thus fortified mentally, has sufficient grounds for asserting that the postulate that gravitation (or any other force larger than unity) conceived as a continuous force is a convenient but untrue generalization. The fact that the formula when modified by the proper constant, will work closely enough for most of our experiences, does not prove the truth of the assumption of continuous force. In fact, if the force were continuous, it could not be thus modified into a finite quantity. The formula does not give even appropriate accuracy in all cases; and, philosophically, it is quite unsound.

We see what appears to our dull eyes to be curves in falling bodies, and we are unconscious of the infinitesimal intervals when gravitation fails to force the bodies down. Hence we call the series of straight lines a curve, and, say, grossly enough, that gravitation is unceasing. This is sufficiently correct for most practice, but the error comes from the fallacious concept. Many of our theory-makers use these erroneous but practical generalizations of mathematics as if proper criteria of exact and reasoned truth, and thus reach improper conclusions. This has been our great error.[1]

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[1] As professor Whitehead says: "The success of their ultimate ideas con-

In the earlier example, ten million foot-pounds of force are *not* being delivered continuously during the whole duration of one second; and the practical working formula which assumes continuity of force-delivery during the entire period is fallacious in theory. Continuous force-delivery might be a possibility in some solid and unified universe other than our own, but this idea does not particularly interest us, for it has no bearings on things as they are here. We should understand, therefore, that misconceptions like these are now being drawn from fallacious mathematical generalities. These errors should be disclosed. The formulas should at least be reinterpreted so that they will no longer mislead us in our theories, and so that they will apply to our particularities. We do not wish to misinterpret the physical truth by even one-trillionth; and we wish our philosophy to be as perfect as possible.

Abstract mathematics, then, is not to be valued for more than it is worth. We must not assume that it can demonstrate the particular truths about our universe of things. If we wish to use a long bridge supported only partly by short physical piers as a quick means of stepping over the empty spaces that lie between the material corpuscles, we are often justified in doing so; but, provided only that we have the wisdom to realize what the long averaging step really means. Under this bridge lie both reality and unreality as regards physics—that is to say, both things and mere emptiness exist there—and so, if our experience should ever deal with the physical facts only, the bridge which was helpful for spanning long distances containing both matter and non-matter, will be found an impediment to knowledge. We must remove its planking if we are to examine the separated piers. At times we must even abandon this convenient walk-way and revert to the minuter fact—as it is. In our examination of the minute physical reality, no formula will apply which is composed partly of vacuum. And because our mental structure has spanned long averages in a satisfactory way, we

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firmed scientists in their refusal to modify them as the result of an inquiry into their rationality.''

must not suppose that this means that the matter supporting the bridge is really continuous.

We must realize also that there are five piers of solid matter for every four spaces of emptiness between, so that even the averaging formula, unless very carefully and knowingly constructed, will contain its error, an error that will grow larger as the particular is approached. Nor can we identify the edges of the piers exactly.

Helpful as the inclusive generalizations of mathematics are, we seem to have gone beyond this helpfulness. We have been inclined to forget what our formulations mean, and that they have been developed from imperfect experiences. Thus we have mistakenly regarded them as infallible. We have also glorified the nothingness between the corpuscles into an unreal importance—as if it were something. We have made much of this void; we have even contended that it had physical actuality; and we have done this merely because it was a part of that which lay unperceived under our useful mental bridge, and which, in this way, seemed a part of a structure which was proved by practical experience to be real from end to end. ''Does not this total utility demonstrate,'' we ask, ''that there is no gap of unreality under the bridge; that this which you are inclined to call nothingness is somethingness after all?'' ''If this material emptiness can take its place in a practical formula, isn't it thus proven true and real of itself?'' ''Or, haven't we proved rather that there is no emptiness, and that physical reality may be continuous?'' ''What experience can prove otherwise?'' If we agree to this plausible argument, we must believe that a line can be continuously real even by means of nothingness. And, force, likewise—can it not be proved continuous by the same reasoning? May we not argue then (as some do) that motion can be deflected by nothing more tangible than curved space-time?

Indeed, let us now question whether this failure on our part to separate the real from the unreal in the working formulas of a generalized mathematics is not the chief cause of our philosophical mistakes. Have we not discovered here the reason for our present confusion of ideas? Isn't our use of a mathematics of continuity (and one which is regarded as exactly true in its application to physics) the chief cause of our difficulties? Surely this inclusion of the unreal with the real in our theory has been a drag to a finer knowledge. Doubtless, because of this error, the physicists have recently discovered that many of their old rules cannot be used successfully as regards certain conditions—these conditions, indeed, in which an averaging of matter with voids in a generalization does not prove practical. In its finer relations—that is to say, when it has to do with one pier—the averaging formula which takes in pier after pier, as well as the empty spaces between, proves inadequate.

Our mathematics does not solve many of our more delicate problems, for the minute relations invariably approach the solid characteristics of the things-in-themselves. To these our only real continuums, the rectangular measurement-systems of Euclid do not apply, and the factored formulas of mechanics are equally irrevelant. In reference to certain relationships our abstract mathematics is mere gibberish; and that percentage of gibberish which does now obtain, while larger in some cases than in others, is useful nowhere in a philosophic sense. A corrected mathematics, one referring to the real things of the universe, might serve every purpose.

Oswald Spengler asserts that "numbers are images of the perfectly desenualized understanding of pure thought; and contain their abstract validity within themselves."[1] I should rather say that numbers receive their meanings from the homogeneous and probably spherical smallest bits of matter, and the separate or abstract validity of numbers is either nothing at all, or else is worth less than nothing to us in physics because it misleads. These smallest bits may be quite unknown; that is to say, we may never have had recognizable physical experience with them one at a time; and we may never have examined the inner being of one of them; but this building-block, this true unit, the "one" (1) of mathematics, is a reality, nevertheless, in its inertia, in its form, in its area, volume, and solidity, in its acceptance of motion from other moving bodies, and in the structural arrangement to which it will subscribe when receiving motions as it does receive them. Through experiences with it in group-formations, we can even deduce its chief characteristics, and we can interpret also the environment which thus affects it. This inert bit of matter is real physically, therefore, and also as a mental concept, and it may become real to our understanding.

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[1] Oswald Spengler: *The Decline of the West,* p. 67.

Spengler says of numbers, however, that:

> Their exact application to the actuality of conscious experience is therefore a problem in itself—a problem which is always being posed anew and never solved—and the congruence of mathematical system with empirical observation is at present anything but self-evident.[1]

Why should we not expect to discover a congruence between a proper mathematics and the physical nature which it is to interpret? Must not mathematics, so far as it is to be true and dependable, be founded on nature? Spengler asserts that Euclidean geometry is in agreement with the phenomenal world only approximately and "Within very narrow limits—in fact the limits of the drawing-board," but I should say that geometry (except as a system of direction-lines) is abstract and unreal long before it reaches the imagined but unreal curves of the draughtsman. The geometry which we have derived abstractly is true only within the continuity of the smallest and the only solid particle. And Poincaré was approximately right when he wrote: "What we call geometry is nothing but the formal properties of certain groups, so that we can say—space is a group."[2] And again: "If there were no solid bodies we should not have geometry."[3]

Newton himself wrote in the preface to the *Principia:* "Geometry is based on practical mechanics and is merely that part of general mechanics which explains precisely and demonstrates the art of measurement." And Hemholtz said later: "The axioms of geometry are not concerned with space-relations only, but also, at the same time with the mechanical deportment of the solidest bodies in motion.[4] And Poincaré remarked again: "One geometry cannot be more true than another but only more convenient. Geometry is not an experimental science [In one sense we must disagree with this]: the space which it studies is our creation, but it it adapted to the world in which we live."

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[1] *Ibid.*, p. 67.
[2] Raymond Poincaré: *Derières Pensées*, p. 50.
[3] Poincaré: *La Science et l'Hypothèse*, p. 80.

Even the formulas of the differential calculus which are supposed to permit us to obtain the exact rate of change, at a certain time or place, of two mutually dependent variables, have their percentage of error. They approach the actuality closely only when the generalization is of fairly large proportions. And, because of their basic unreality, they fail to give answers to many problems, and misinterpret many facts. Seemingly simple propositions often cannot be solved by this unreal mathematics—no more than the unreal circle of composites can be measured in terms of squares, and no more than a square can be measured in terms of a circular unit of area. The use of these formulas often proves gibberish—so much so that a guess gives closer results. To prove practical universally, our mathematics must be made to correspond to physical nature—and this, to-day, it does not do.

The assumed line of Euclid has no breadth. According to the abstract geometrical representation billions of lines might be placed side by side without approaching the dignity of an area. Indeed, physical area would be meaningless if there were nothing to be placed inside of an abstractly conceived volume but such imaginary lines. How, then, we ask the conventional mathematician, can we multiply one line by another and obtain an area for our product, and a formula for area even applicable in physics? How can one say that one line has a length which may be called "4," that another line also equals "4," and that the two multiplied together gives an area which equals 4 x 4, or 16? Yet geometry of lines without breadth postulates such a result, and the schoolboy is usually required to accept it without question or explanation. To one of inquisitive mind it would seem futile to expect a visible area from the squaring of widthless lines. If two lines without width may be multiplied into an area, why not develop solidity from the multiplication of two velocities? Surely if we are to get meaning out of geometry we must abandon this shadowy line and adopt a physical line —a row of things as they are. A real physical area, and also a volume will then come from this row of things,—and from each one of these things provided it is not composed of lines alone but is solid and real throughout,—and we shall then understand why the formulas of geometry apply fairly accurately in physics. We can then perceive the meaning and reality of certain mathematical theorems, and the unreality of others.

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[4] Hemholtz: *Popular Lectures,* 2nd series, 1888, p. 65.

Thus the line numbered "4" should represent the distance which includes four of the smallest particles when lined up in a row. For convenience, any multiple of this tiny line may be taken as our "4"; but if the true unit is to be used successfully to represent a real area, all the other attributes of the unit of matter which constitutes the line must be generalized proportionately. Let us now consider how we arrive at the reality of an area from the so-called multiplication of lines. We shall first suppose that the things which are numbered are touching one another. Then, later, if we separate them a certain average amount, the mathematical proportions will not be affected. The generalized unit will then, in the average, be an almost exact multiple of the true unit, and the physical actuality may be derived approximately from the generalized situation by a proper percentage-factor.

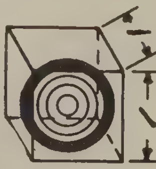
Fig. 2

Figure 2 is the simplest form of geometry. It is the unit sphere (here shown enclosed by a tangential cube) of cold, solid matter by itself. Its diameter is our unit of distance, its cross-section is our unit of area, its volume is our unit of volume, and the arrangements which it actually takes in the finite pool of pressure regulates the possibilities of our Euclidean and analytical geometries so far as they refer correctly to this world. The paths it may take when in motion, furthermore, control the mathematical principles of dynamics, and limit the trustworthy applications of the calculus as applied to forces. Numerically speaking, from whatever view regarded, this rotund corpuscle is our number "one" (1).

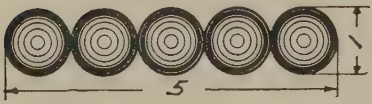

Fig. 3

What have we really done, then, in Figure 3? We have arranged 5 contacting corpuscles in a row. We have therefore attained four separate kinds of 5's, each of which is meaningful: first, the strictly numerical 5, then the lineal distance equalling 5, the cross-sectional area of 5, and the volume of 5. A lineal distance of "5," or a line numbering "5," therefore, has a definite and understandable combination of meanings. A line of things is not merely an intangible direction without meaning as regards width, or depth, but rather it is a row of bodies such as the things are, and with all of their material characteristics, length, area, mass, inertia, and volume—and these physical attributes increase in the same proportion that the numbers standing for the parts of the lines are increased. This fact makes our geometry meaningful in, and applicable (when factored) to, physics. Thus viewed, the physical basis of geometry is readily understood. When one perceives the physical aspects hidden in our meanings of numbers and lines it becomes plain how the generalized number of a line may be multiplied by the number of another line, and how the generalized numerical product will represent, in a certain multiple, both physical area and volume.

A line, we now understand, is never really multiplied by another line. There is no multiplication except as regards numbers. One fumbles with language when he speaks of the product of two lines. A line is nothing but a row of things, and the "number" properly given to a line refers to the sum of the number of things that the line contains. When it is said that a line "2" can be multiplied by a line "4," and that the product will be a rectangular area of "8," what is meant? Simply this: A line containing two physical things, and, therefore, certain physical attributes, can be taken four times. However these 8 things are arranged, the physical results will always be the same. In Figures 4, 5, and 6, three different ways are shown of summarizing four (4) lines each composed of two (2) things. In every case there is the same totality of number, of distance, of area, and of volume. In every case the physical attributes represent eight (8) times the quantities contained in the unit of matter.

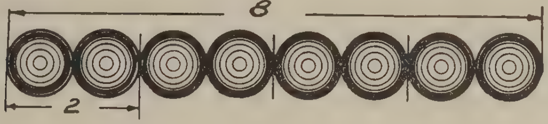

Fig. 4.

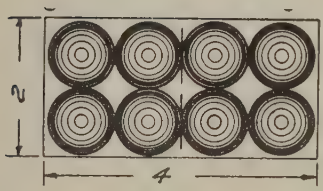

Fig. 5

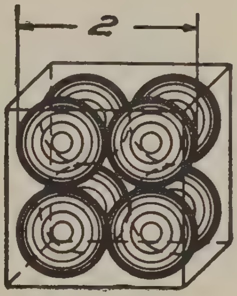

Fig. 6

Geometry tries at times to be strictly abstract, attempts to divorce itself from the properties of the numbered corpuscles, to imagine rows of uniform empty spaces, to do many unreal things. It is unable, however, to leave the earth, and to develop in empty space a science fit for this earth. Because he fails to perceive that the characters of these things explain certain discovered principles, the student of geometry is apt to accept (undigested) the mysterious reasoning that the product of a widthless line by a depthless area is a volume. Then, having used what are regarded as pure abstractions fairly successfully in the first stage, and having attained practical results thereby, merely because the true relations of the things themselves were included unrealized, the mathematician often becomes increasingly bold and carries his abstractions far into the unreal—even into realms where his formulas will not fit accurately the physical world as it is. His mathematics will not apply to the delicate particulars of the universe, and is not useful as a means of explanation. Thus one may use mathematics to prove that the orbit of any planet may be the continuous curve of any conic section; but the proof is unsound, for it is made by use of an unreal and inaccurate mathematics which postulates infinities and infinitesimals in the material world—and even infinitesimals which may (without weakening the truth) be dropped out of the formula of the calculus. In fact, no section of a cone is a curve.

We "know" the heart of the matter-particle—Kant's "thing-in-itself"—only by its phenomena in so far as they can reach our minds; but, as Locke believed, the quality of the "thing-in-itself" gives us our facts of extension, impenetrability, figure, motion or rest, and number. Other qualities also bubble up from this spring of material identities—but we shall consider only the mechanical attributes here. Schopenhauer said that "Mathematics is based on perceptions, on which its demonstrations support themselves," but he did not regard the perceptions as empirical, but as *a priori,* and, therefore, as necessary. Here is revealed the error. The principles of abstract mathematics are held erroneously to be necessary in physics, whereas, as founded, it would seem partly to have avoided physical necessity.

According to Spengler—

> Whereas number, as conceived by a Pythagorean, exhibited the essence of individual and discrete *data* in "Nature" Descartes and his successors looked upon number as *something to be conquered,* to be *wrung out,* an abstract relation royally indifferent to all phenomenal support and capable of holding its own against "Nature" on all occasions.[1]

This states the case very explicitly. Descartes and his disciples, to my mind, have erroneously attributed the glory of physical reality and being to these numbers, which, after all, are nothing but modifying adjectives depending for their significance in physics upon the relations of the things unphysical to which they refer.

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[1] *Ibid.,* p. 88.

John Stuart Mill reached a far more rational conclusion. He said:

> All numbers must be numbers of something; there are no such things as numbers in the abstract. *Ten* must mean ten bodies, or ten sounds, or ten beatings of the pulse.[1]

And he spoke with some truth when he said of geometry:

> Since, then, neither in nature, nor in the human mind, do there exist any objects exactly corresponding to the definitions of geometry, while yet that science cannot be supposed to be conversant about non-entities; nothing remains but to consider geometry as conversant with such lines, angles, and figures, as really exist; and the definitions, as they are called, must be regarded as some of our first and most obvious generalizations concerning those natural objects. The correctness of those generalizations, *as* generalizations, is without a flaw: the equality of all the radii of a circle is true of all circles so far as it is true of any one: but it is not exactly true of any circle; it is only nearly true.[2]
>
> The peculiar accuracy, supposed to be characteristic of the first principles of geometry thus appears to be fictitious.[3]

Or, as the more modern writer puts it:

> Conventional mathematics does not correspond to the physical reality; it cannot easily make a qualified statement subject to limitations, and it recognizes no difference between the physically big and the physically little and the corresponding change in the operational meaning of its symbols. It begins by being a most useful servant when dealing with phenomena of the ordinary scale of magnitude, but ends by dragging us by the scruff of

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[1] J. S. Mill: *A system of Logic*, 1925 Edition, p. 167.

[2] *Ibid.*, p. 148.

[3] *Ibid.*, p. 149.

> the neck willy nilly into the inside of the electron where it forces us to repeat meaningless gibberish.[1]

The question of the valid use of numbers in physics is not as simple as it may have seemed. There is another point of view. Mr. Bertrand Russell, who represents an important school of modern opinion, thinks that numbers *should* be applied to the properties of the classes only, and that two classes indistinguishable as to properties by the sense-data should receive the same arithmetical treatment. He believes that this view is justified on the grounds of proved practicability, and also because there is no sound argument against it. We have never, he thinks, received realizable sensations from the "thing-in-itself," therefore why try to include its properties in our number-system? Why should we attempt to designate by a number in a mathematical formulation a class of properties which is never known separately, which cannot be distinguished from some other class? He argues that we can properly apply numerical distinctions only to those things that we can "know" up to the point of distinguishing them or their effects, and we cannot thus "know" and separate the properties of the unit things. Can we, for example, ever know that there *is* a unit of matter as distinguished, or distinguishable, from a unit of force?

Now, doubtless there is truth in the view that a generalized number-system has practical value when used in regard to types of realizable composite phenomena. Indeed, we have already admitted this. But, to how false a philosophy it has led in treating of this world as it is!

Mr. Russell, we think, carries his argument much further than is justified. He says, for example, that numbers *cannot* be applied both to the properties of the "thing-in-itself" and to classes (composites), because the properties of the class are never the same as, and are never even related to, the properties of the "thing-in-itself." For this reason he regards the use of numbers as applied to the unit thing as positively incorrect. Thus he remarks: "If, in any sentence in which a thing is mentioned, you substitute a class for the thing, you no longer have a sentence that has any meaning.''[1] For example, the substitution of ''mankind is eating apples'' for ''John is eating apples'' does not make sense. After such an argument he says: ''Now, if nothing that can be said significantly about a thing can be said significantly about a class of things, it follows that classes of things cannot have the same kind of reality as things have; for if they had, a class could be substituted for a thing in a proposition predicating the same kind of reality to both. This view is really consonant to common sense.''[2]

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[1] P. W. Bridgman: *The Logic of Modern Physics*, p. 149.

The argument is weakened by being made conditional, the ''if'' being introduced, but the last statement is positive—at least in its implications. Mr. Russell apparently believes that no intelligent person should regard numbers as applicable to the properties of the assumed invisible unit of matter, and he accepts this point of view (which is the basis of much of his philosophical scheme) in an argument that appears to us to be surprisingly incomplete. Of course, we strongly question his assumption. We regard it as fallacious from more than one count. ''John is eating apples,'' in the reference above, is an even necessary condition to the truth of the statement, ''mankind is eating apples.'' The property of the class is composed of the property of the unit repeated through space and time. Unless every single man were eating apples, mankind could not be eating apples. Mr. Russell, however, as he proceeds, seems to gain confidence, until finally he is ready to accept the conclusions of the German, Gottlob Frege, who attempted to analyze mathematical principles, as being *definitely* sound. He says: ''It is not physical objects, but classes or the general terms by which they are defined, of which numbers can be asserted.''[3] There is no conditional ''if'' in this statement.

Mr. Russell acquires confidence in his view as to the proper use of numbers from the fact that it seems to afford a satisfactory explanation of the hitherto puzzling meaning of the number ''zero'' (0). Zero, he says, may be the property of a general class, such, for example, "as the general term, 'satellite of Venus,' because Venus has no satellite." "Here at last," he proceeds, "we have an intelligible theory of the number 0." Yet we cannot see why, if numbers were applied to the properties of the unit thing, the absence of the unit thing could not be regarded with similar reasonableness as representing physical nothingness (or zero) as to matter and its properties. The argument for this concept of zero has already been set forth in this chapter.

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[1] Bertrand Russell: *Our Knowledge of the External World,* p. 223.

[2] *Ibid.,* p. 224.

[3] *Ibid.,* p. 221.

Mr. Russell is willing to apply the tags of numbers only to the attributes of groups or classes that can be experienced empirically, only to properties that are surely real and surely different from other properties with other number-tags—the proof of the fact of difference being determined only by the specific sense-data themselves. He thinks, too, that only the properties of composites (or classes) can be included in this category, for he believes that nothing can be known of the real distinctions of the physical universe except through the medium of a specific experience involving one of the organs of sense as it has relations with the properties of one of the classes. He thus attempts to justify a type of generalized mathematical formulation that seems to suit the concepts that physicists have attained through specific experiences referring, as they have, almost exclusively to classes. He leaves no place for a concept reached through a mental operation that comes to the conclusion that certain unperceived things must be so because some other perceived things are true.

Yet it seems rather obvious that if mathematics is to be suited for universal use in interpreting the mechanics of the world, it must often be used in cases where the action of the unit of matter, and not the action of a group, has sway; for all the matter in the universe is not gathered into these classes of Mr. Russell's concept where energy-deliveries can be directly realized by the organs of sensation. Indeed, we have every reason to suppose that at times these separate and unperceived particles have profound influences requiring quite different mathematical formulation from that which is possible if numbers are applied only to the properties of classes. We must suppose that at times the addition or subtraction of one unit-delivery of energy by the "thing-in-itself" will create an important and finally realizable change in the physical environment. The quantum-phenomenon is one strong proof that this is so.

If, therefore, the concept of a proper mathematics has been taken incorrectly, with the result that the numerical distinctions of properties are inadequate because too grossly applied, and if the distinguishing number-tags separate only the class-properties, as Mr. Russell calls for, then the use of this generalized number-system will, at times, afford a proof of something even the reverse of the truth. A mathematics composed of such wide-spread distinctions will never be *exactly* correct in any of its applications, will never afford a precisely true answer, and will often give quite a wrong directioning to the philosopher who accepts the mathematical conclusion as being a final proof both as to fact and theory.

Mr. Russell says that neither philosophy nor pure mathematics "depends upon the actual concrete facts being just what they are."[1] Now this statement may be *almost* correct in so far as it refers to the usual situation to which mathematics is applied but, unfortunately, after a faulty mathematical system has been adopted for unqualified use, after the correct philosophy of the use of distinguishing numbers has been misconceived and misapplied ever so slightly, the mathematician confidently uses this faulty system in cases where it cannot apply even approximately. The philosopher, too, accepting the faulty proof of the faulty system, is led astray.

Mr. Russell takes the rather odd view that the true mathematics and true philosophy will apply to all abstractly (or imaginatively) possible worlds—and yet, obviously, one world only, so far as we know, *is* actual. He goes so far as to say that "any quality, therefore, by which the actual world is distinguished from other abstractly possible worlds, must be ignored by mathematics and philosophy alike.[2] This sentence almost seems like a return to our point of view, at least if we think of all worlds as being composed of matter with inertia, for when we try to think of what set of physical properties might appear in all possible worlds of matter in motion, we can think only of the properties of the "thing-in-itself," as expressed either by itself or as grouped in a structural (or class) relationship of some permanence. And we can readily imagine a world in which there are no fairly permanent classes-groupings like our atomic elements—but only haphazard quantum effects. Mr. Russell, however, does not accept these implications. He continues to argue that the properties displayed by the "thing-in-itself" never should have any part in creating the distinctions tagged and formulated by the use of distinctive members, for the attributes of the thing can never be "known" separately, he thinks, in any way that requires separate classification or formulation—in this world or in any other.

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[1] *Ibid.*, p. 202.
[2] *Ibid.*, p. 202.

Now we believe that here he has taken a stand which is erroneous in more than one respect. To begin with, he ignores the possibility that a mental or spiritual power might affect physics, that some spiritual influence outside the definition of the mechanical properties of a class might create a new set of mechanical conditions entitled to a new distinguishing number-tag in mechanics, or a new formulation. Passing this by, however, let us consider his view that the specific sense-data are the only means by which we obtain knowledge of physical facts, and, therefore, that only the distinctions of physical properties as disclosed by specific sense-data are entitled to distinguishing numbers.

It appears that the properties of the composite, as they are recognized by what are ordinarily regarded as our organs of sensation, and therefore, as they physically exist as sources of these sense-data, are due to a combination of characters, first, the quality of rigid inertia which is possessed only within the volume of the unit "thing-in-itself," and, secondly, either the straight-line-reversed or cyclically-reversed movements of this unit thing,—a reversal which, as our more delicate instruments disclose, is always to be discovered within the volume of the usual composite structure with which physicists treat,—and, thirdly, duration. So far as the properties of the fairly permanent structural group are concerned, the reversals of the motion of this smallest particle within the formation in question, and its consequent series of momenta delivered at the bounds of the structure, permit the composite to express unbalanced energy (as received from the outside) into volumes exterior to it in that systematically regular way which, at times, reaches man's organs of sensation. When the ''thing'' is thus grouped in a fairly stable and symmetrical structural formation, and then, when, in addition, radiations of energy-units are caused by unusual energy-receipts from one direction, the composite delivers portions of its vibratory momenta to the exterior world in a fairly regular series of energy-effects; and while this energy-series represents nothing more than the unit-blow repeated through time (the duration itself and the regularity of the time-intervals between the separate blows being the new ingredients of the situation), nevertheless, this regularity of repetition permits man's organs of perception to be conscious of this series of events although unaware of the single events of which the series is compounded. Thus a single air-vibration has no sound-pitch although when repeated in a regular series it gives to the parts of the ear the intensity of vibration that is known as the sensation of a musical pitch. Also, a single emission of light has no colour-effect, no corresponding sensation-tag that may be found on the spectrum, but, when repeated with a sufficient frequency and in a regular series, this unit-emission (this quantum of energy-delivery, perhaps) will build up that intensity of vibration in the physical organization of the eye which is ''known'' as a certain sensation of colour. And, as we may perhaps assume that only a finite number of frequencies of light-emissions are possible from the limited number of structural classes of the elements with which we deal, we may perhaps assume that the spectrum itself is not a continuous blending of shades, as some may suppose, but is composed of a finite number of colours which are separated quantitatively and qualitatively, and, which, therefore, may be distinguished one from another by an appropriate numeration.

In any event, the single blow of the smallest bit of matter is the true unit of mechanical energy, and is also one of the units of the mechanically-created vibrations in the ear or eye which are known as hearing or seeing. Nevertheless, it seems unquestionably true that we usually see and hear through a relationship with certain group-formations known as the physical "elements." Probably the organs of sensation (composed as they are, too, of these same elements) were purposely developed to record the type of repeated blow that is derived from the symmetrical groupings of the atoms in these elements. Only thus could we become aware of our usual environment, and distinguish its classes by use of our sense-organs. Every mechanical energy-delivery of our environment, however, every possible contact from which we might acquire knowledge, is composed of rigid inertia plus motion, whether it be the unit blow or that series of blows which conventionally produces the usual sensation of sound or colour. In fact, the sole property which the unit blow does not possess in common with the composite effect, is duration, for each unit of energy-delivery (as has been proved) is instantaneous, whereas the composite effect occurs in a series which, as a series, requires a spread of time.

Now it seems rather obvious that the only way any group-or-series-effect can be properly enumerated (and thus be exactly distinguished through the use of number from some other effect having the same relative velocity of motion), is by the application of the number "one" (1) to the properties of the unit blow, and also by the application of the other numerals of the number-series to the respective number of repetitions of the unit blow as similarly delivered within a certain interval of time. Unless the different class-effects were thus formulated there could be no mathematical way of distinguishing exactly by the use of numbers between the properties of two similar class-effects (two colours, for example), for the effects differ only in respect of these slight variations in the frequencies of the unit blow. Furthermore, if it be true that the sensed composite-effect is the result of a series of unit-effects of a certain frequency, then Mr. Russell is obviously wrong in assuming that "classes of things cannot have the same kind of reality as things have," for the reality of that which gives the class-sensation, as we have noted, is merely the repeated reality of the unit-effect built up by a regular repetition to a vibratory magnitude perceptible to our organs of sensation.

It is quite possible, moreover,—and certainly it has not been disproved,—that in certain situations either the haphazard series of blows (which, of course, is not the normal class-effect) or the single unit-blow can be sensed. And even if the single blow can never be sensed directly through the activities of such physical organs of physical sensations as ears and eyes, an effect finer than that possible to perception may nevertheless be ''known'' (or realized) through a mental judgment that permits us to make finer distinctions between the properties of really separate classes than those that can be reached either through one specific sense-datum relating to the one class or through the data of two classes that are to be compared and distinguished. Indeed, Mr. Russell has illustrated how this may be done.

Let us suppose that a shade of colour ''B'' cannot be distinguished from shade ''C,'' and that shade ''C'' cannot be distinguished from shade ''D,'' but that vision can distinguish between ''B'' and ''D.'' Now this fact will prove to the reasoning mind capable of making an abstract judgment that there is really a physical distinction (doubtless a blow-frequency-distinction) between colours ''B'' and ''C''. This relative truth has been determined beyond question even though the distinction between the specific properties of ''B'' and ''C'' cannot be made by the vision. If, therefore, the mind relies on the specific physical sensations alone for its revelations of specific truth, it cannot reach the more correct conclusion that is here open to it through this other means of acquiring knowledge. The specific empirical experience, as gauged entirely through an interpretation of the specific sense-datum, is not, therefore, always the most reliable authority for arriving at the most accurate knowledge of a certain physical fact. At times, the reasoning mind can reach a sounder conclusion through its analytical judgment of a broader or different set of sensations. We therefore conclude that the seeming accuracies of distinctions (or lack of them) between the properties of physical classes as attained from the sense-data directly bearing upon these classes, may otherwise be proved inaccurate. This being so, the fact that the specific sense-data cannot be used for the purpose of making a distinction between two classes of physical properties does not necessarily justify the use of the same property-number-classification for the two classes.

Indeed, in such cases where the distinction can be clearly made only through such a process of reasoning, the application of the same number to each of the two (really different) classes obviously lacks mathematical accuracy. This possibility of misapplying numbers when the specific sense-datum alone is the criterion, and the further proof that in some cases this method is clearly inaccurate, places the burden of proof, we think, upon him who wishes to rely upon the specific sense-data as the best guides to a correct number-system, or who feels that it is possible that such a treatment could arrive at the soundest mathematical formulation for use in physics.

The reasoning mind, moreover, which alone permits us to realize this distinction between two otherwise indistinguishable sets of physical properties, is different in quality from the sensations that it makes use of. This fact is proved. It is obviously possible, therefore, to apply numbers to physical reality in a mathematical system that formulates the facts more correctly than can be done according to Mr. Russell's system. And it will be a bold or exceedingly wise man who will try to set the limits to the exactness of knowledge that the reasoning mind can attain by forming general judgments from all the experiences of life—that is, by general deductions as to what things must be.

Indeed, if reason, or a deduction drawn from the most general experiences, ever informs us that a certain physical effect must have taken place as the result of a single blow received from the unit "thing" in motion, then the effect of this unit-blow will have been made real and vital to us, and it can no longer be ignored and left out of mathematical formulations professing to possess the greatest practical accuracy.

Now I claim that in many situations the composite-or-group-effects are so perfectly balanced that the single unbalanced unit-blow *must* be able to create the finally perceived motion-effect of the whole. The weight of the last straw breaks the camel's back, even though the back has the strength of an enormous class, and even if the weight-force of the last straw is nothing but the immeasurable momentum of a single invisible electron. At a certain stage in the progressive addition of unit-effects the collapse occurs, and in such wholesale fashion that the effect of the last unit-addition of force can be clearly perceived. The collapse of the class tells us definitely of the presence of the immeasurably small and imperceptible increment of force, which if physical nature is granular (as it must be, judgment tells us, if it is not solid throughout), must itself be the unit granule of force which causes the collapse.

A progressive series of unit contacts, furthermore, must cause first, the slowing down, and, finally, the reversal of the motion of the pendulum at the end of the stroke. We cannot perceive the units of the slowing-down, and we cannot tell exactly when motion to the left ceases, or when motion to the right begins, but we realize that one last immeasurable unit-blow towards the right must have created the first motion in this direction; and we realize, too, that the effect of this unit-delivery of motion, even without further increment, will finally be perceptible. Moreover, the fact that motion can be reversed itself permits us to realize definitely that there is no continuity of physical energy-relationships in space and time such as some physicists are willing to imagine as the best way out of their conceptual difficulties. The very reversal signifies that there is an edge or ending which breaks into the idea of continuity.

And, then, again, who can fail to realize that there might well be in this world a massive tower so perfectly balanced on a thin edge that the impulse of one unperceived blow—a momentum of no greater magnitude than the granular quantum of energy—will, by striking the right rather than the left side of the mass, cause it to crash down to the right instead of to the left. The quantum-blow in this case would not, of course, cause the effect of the crash of the tower, but it would control the place of the fall, and thus the unit-blow, at the critical stage of perfect balance of much greater forces, is the most important factor in the situation. Certainly one cannot afford to disregard it in any mathematical formulation that proposes to represent exactly the properties of the physical situation, or that purports to show the way to the physical result as it concludes.

Reason seems to inform us definitely that, in this universe abounding in relatively unorganized particles of matter delivering invisible effects different from the regular series of blows from the elements to which our organs of sensation conventionally respond, there are many crucial and finally perceptible results that must be attributed to the imperceptible delivery of energy in unit-quantity. Obviously, then, the influence of the properties of the unit-thing must be decisive in many cases, and must cause results readily realizable through time and space. This must be so even though no organ of perception permits us to be aware of the unit-effect at or during the time and space that the effect is being delivered. Having this rather definite understanding we cannot feel mentally justified (except on the grounds of practicability in ordinary engineering) in using a number-system in which unity refers not to the properties of the thing-in-itself, but to the wide-spread properties of a class.

Now Mr. Russell, in his need of justifying his quite different opinion of the proper use of numbers in physics, neither denies nor accepts the fact that there is a unit of indivisible matter. He thinks it unnecessary to attempt to reach a conclusion on this question. He prefers at times, it would almost seem, to think of a number, not even in terms of the properties of a class of things, but as a something almost purely abstract—and yet still, somehow, useful as a means of interpreting events in the physical world.

He introduces the idea of incommensurables as a further proof that numbers cannot be applied accurately to the actual things of the world. If he had preferred, however, he might (and perhaps more logically) have accepted the presence of irrational numbers as proof that the number-system had not been rationally organized. If the unit of number had been applied to the properties of the unit of matter, as we claim it should be, incommensurables would be unknown in physics. The fact that there are incommensurables in the mathematics of geometry, is itself proof that our number-system is erroneous, and our physics unsound.

Pythagoras, long before the Christian era, discovered that the diagonal of a square cannot be expressed in terms of any whole numbers that may be given to the sides of the square, although Euclid proved in general terms of any right triangle (and the square is split by the diagonal into two right triangles) that the square of the number representing the hypothenuse (here the diagonal) must be equal to the sum of the squares of the whole numbers that may be given to the sides of the square. Pythagoras kept this seeming irrationality a secret because he believed it disproved his philosophy of numbers. Mr. Russell, however, accepts the fact of incommensurables as a proof that numbers should not be applied to the properties of single things. Numbers, he claims, are parts of an abstract system. Nevertheless they should refer to the properties of matter with sufficient accuracy to be useful to the extent required in physics. He says, for example that: "The number 3 is something which all collections of three things have in common, but it is not itself a collection of three things." It is "something more abstract than any collection of three things." He finally asserts that: "Numbers, in fact, must satisfy the formulas of arithmetic; any indubitable set of objects fulfilling this requirement may be called numbers." This, of course is no explanation of the proper use of number, but in using the phrase "satisfying the formulas of arithmetic," he apparently means that the number-system and its formulation must correspond with what seems to be true according to our relatively gross sensing of specific experiences. He does admit, however, that the quantum-phenomenon has never been brought under the mathematical formulations arranged according to this theory. He apparently hopes that some day it will be.

Naturally, Mr. Russell's ideas of the units of time and space to which numbers should properly refer are similarly generalized. According to him no event need be regarded as instantaneous, for two events can, for all practical purposes at least, be regarded as running through space and time like parallel lines with ends constantly over-lapping, so that, looked at from the side, the event seems to the gross vision to be continuous in space and time. His theory of mathematical instants suitable for mathematical formulation is based upon the assumption that all mechanical events consume finite time, and therefore can over-lap in time, whereas, according to our view, unit-events are instantaneous and cannot over-lap. He, therefore, is willing to use one number to indicate a relatively gross time-interval, one which we conceive as being composed of several parts that should be distinguished numerically because of the fact that many important events may take place separately within them. We admit, however, that in taking this view of the meaning of an instant of time in mathematics as a fairly wide-spread duration, he is being fairly consistent with his theory that numbers should be applied only to the properties of classes, and to the series of regular blows received from a class-group (while radiating), because these alone are realized by men through their sense-organs. Not only does the class, or group, require a definite duration in which it may create that unit of appreciable intensity of vibration in the sense-organ, but the group requires a certain spread of time in which it may display its relative stability, and thus give evidence that it is really a grouping of a kind that may consistently display the properties of a class.

If a class, like a bomb, should immediately explode after organization into the bomb-structure, then, according to Mr. Russell's view of time, it would never have been a bomb. It must remain, we suppose, in the class-formation long enough to give off that series of radiations which are recognizable to the senses, if either its typical reality in time, or its numbering as a class-organization, is to be justified. Only the material universe can be recognized as a whole entitled to be designated by the unit one of number while its parts are moving around from place to place without giving specific sense-data to anyone, and Mr. Russell does not attempt to consider the universe as a whole.

One wonders how, according to this theory, we should use numbers in some other world where our sense-organs were so constituted that they could easily distinguish the effects of the separate blows of the ''thing-in-itself.'' Perhaps certain forms of life on this earth can now make these distinctions. Under such conditions Mr. Russell's theory would fall to the ground according to his own admissions. Certainly if the human faculty of perception should suddenly reach this fineness, the mathematical system of Mr. Russell's preference would be disclosed as obviously and rather grossly inaccurate.

Now his number-system, deliberately arranged so that a distinguishing number-tag is attributed to that rather wide-spread part of space and time which permits of the delivery of a series of blows perceptible by the sense-organs, not only satisfies Mr. Russell on the grounds of logical fitness and convenient practicability, but it particularly appeals to him from the fact that it seems to permit him to retain those concepts of continuity and infinity which he finds almost necessary if he is to be able to explain events according to his other preconceptions. Even the famous argument of Zeno, the Eleatic, that our idea of motion is unreal because space must be divisible into an infinite number of portions which can be traversed only in an infinite time, seems to Mr. Russell to be answerable only if his theory of extended space-points and time-instants is true. He does not conceive apparently that the conventional theories of the planetary orbits, of gravitation, of the tides, of light, of cohesion, of elasticity, of radiations, might all be basically false, and that the very foundations of mechanics might need rebuilding.

Mr. Russell, I think, is in error when he makes the statement that ''When we assert that some mathematical account of phenomena is correct, all that we primarily assert is that *something* definable in terms of the crude phenomena satisfies our formulae.''[1] We have long held this false concept of what constitutes an adequate mathematics, and it has led us into many difficulties and paradoxes. No mathematical accounting is exactly true—ever—unless it is true of every event.

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[1] *Ibid.*, p. 155.

Nor is it true unless it satisfies that which reason tells us must be true of the unit event. This is so even though we cannot identify through our sense-organs what actually happens.

It is strange that the physicists do not generally recognize the truth of the following propositions: (a) through reasoning about the broader experiences of the world a finer knowledge can be attained than that which the specific experiences in question disclose as sense-data; (b) it is possible to set up a mathematical formulation that will correctly and adequately apply to every physical experience of the world, whether it be a unit or a composite phenomenon; (c) when the correct mathematical formulation has been attained, it will conform precisely with reason and with every possible type of orderly physical experience—not, however, with experiences in some abstract world that might be, but with experiences in this world in which we live.

It must be clear to the reader by now that it is most important for mathematical accuracy, as well as for a correct opinion of events interpreted through mathematics, that we shall acquire a true concept of how numbers should be applied. To attain this concept so that it will not be open to doubt, we should be obliged to establish and gain acceptance for a theory of knowledge. We cannot well go further with this theory here. We have made the start, but the entire discussion could easily fill a volume. We shall, however, pursue the implications of the theory of numbers, and shall, in the next chapter, consider what we regard as both the proper and the improper concept of mathematics as a science valuable to physics and philosophy both in practice and in theory. We shall close, here, by quoting the view of geometry held by Professor A. S. Eddington, which seems to us to put this science into its proper place. He writes:

> I do not think it can be disputed that, both etymologically and traditionally geometry is the science of measurement of the space around us; and however much the mathematical superstructure may now overweigh the observational basis, it is properly speaking an experimental science.[1]

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[1] A. S. Eddington: *The Nature of The Physical World*, p. 162.

CHAPTER XVII

A CRITICISM OF MATHEMATICS (CONTINUED)

> Apart from abstract propositions of comparison (such as two and two are the same as four), propositions which tell us nothing by themselves about concrete reality, we find no proposition ever regarded by anyone as evidently certain that has not either been called a falsehood, or at least had its truth sincerely questioned by someone else.
>
> William James.

It seems fairly obvious that the effect of a force-action is limited by the solid extensions and masses of the units of matter which the force operates upon; and that the formulated laws which seem to apply correctly to physics—and which, therefore, appear to us to be "necessary"—are merely those principles which apply so closely to certain averaged and orderly relationships (those which we "sense") that the measure of inaccuracy is indetectible. Surely we can say at least that with a different unit of matter the formulas would be different. And surely, also, laws are useless for daily use if they refer only to forms that might exist somewhere in some imagined continuity, but which are without exact reference to the matter-particles separated as they are in our particular world. The quality of matter prescribes the forms which the force-principle may create with matter. Thus the inertia of mass sets the limit to velocity.

Democritus (and later Aristotle) advanced sound principles when he ascribed the revealed qualities of matter to the compositions, figures, and positions of atoms; but his statement would have been more complete had he included the force-principle which gives permanency to a structure composed of moving parts. These parts are revealed to us solely by their motions, by their energy-impulses, but the impulses from one type of atom are recognizable as emanations typical of this structure merely because this atomic structure has a symmetrical organization which delivers energy in a regular series of blows. Democritus knew little of the theory of modern mathematics or of physics. In his day the larger problems were not anticipated. He could have no idea of the meaning of Schopenhauer when the latter said in speaking of the premises of arithmetic that "the results do not answer to the real world lying before us." Yet, having accepted the statement of this German philosopher that "impenetrability is not a mere negative quality, but the manifestation of a positive force", we may believe that the inner being of the "thing-in-itself" (that smallest particle which alone, according to our postulates, is impenetrable, and which, in multiple, gives us our forms, dimensions, volumes, areas, masses, densities, momenta, compressions, and cohesions) must depend upon some exterior force-principle for its identity and its attributes.

Whatever the source of this force-principle may be, and whether this motion of substance, and this impenetrability of the unit-particle, are derived from sources outside or within the boundaries of this smallest bit of matter, we may at least be certain that orderly motion, combined with the impenetrability of the "thing-in-itself," gives the matter-groupings those properties by which they are revealed. Our heat, light, taste, sound, and colour all result from the orderly blows of matter-bodies in series. All our sciences and arts, even our mathematics, therefore, must seek their final reality and practicability in the physical facts true of these tiniest of corpuscles and in the force-conditions which surround them and which cause them to be arranged in certain types of symmetrical groupings and to move with certain velocities and frequencies. Since we "sense" the orderly, it is not remarkable that we can formulate our experiences, for only the orderly is subject to dependable formulation.

Mathematics, then, from the philosophical view should be primarily a science for summarizing unit-characteristics as they appear in multiple in those material structures which conform to the energy-principles of the world-forces at the time that the integrity of the "thing-in-itself" is preserved.

The influence of evolutionary Change is not a proper problem of the geometrician. Let us now consider the conventional geometrical summations for a moment in an attempt to confirm or deny the exactness of their findings.

As has been stated, the internal characteristics of the bits of matter—such as mass, volume, extension, and area—cannot be altered by their motions relative to one another. So long as a particle exists, its totality of inner properties exists within it unchanged by the way it happens to be moving through space. And no reason can be given why inertial mass, as is sometimes claimed, should disappear in some inverse ratio to relative velocity. Nor have those who believed that the inertial mass of a particle may be affected by relative motion ever located or described the temporary storage-place of this property, which is supposed by them to vanish only during the period that the motion continues.

The problems of Relativity, however, do not concern us here; for geometry usually refers to structures and masses which are assumed to be relatively at rest; and ordinary dynamics refers to bodies moving quite slowly. Certainly, in respect of our usual experiences, a structure consisting of, say, thirty-two smallest particles, possesses the same totality of physical mass, volume, and so on, as every other structure containing this same number of particles. Evidently, then, if our geometrical formulas indicate that differences in the sums of these physical properties arise merely from variations in the arrangement of the same numbers of the bits of matter composing them, the mathematics itself must be in error.

In figure 6 and 7, possible ways of arranging eight and twenty-four particles, respectively, are illustrated. There are a cube and a rectangle, the cube containing eight particles and the rectangle twenty-four. According to geometry, a cube, whatever be its composition, has volume and area of cross-section, and a rectangle has area. Even though the numbers which stand for the parts of the line are regarded as being without mass or extension, conventional mathematics permits us to take a line of "two" (2), and raise it to the third power, and thus obtain a cube of eight (8). After the cube is thus formed, it is supposed to have properties which were not contained in the lines: It has volume; but not so the four separate rows of breadthless lines of "two" (2). And the theoretical plane-rectangle, with sides numbered four and six respectively, has a real area of twenty-four, and has it, supposedly, regardless of the attributes of those things to which the numbers four and six (of the lines) refer. Add to the line of four until it becomes six times as long, give it a length of twenty-four, says the geometrician, and the row is nothing but an imaginary and widthless line, a shape without cross-section or volume. If, however, one changes the arrangement of numbered parts composing this line, if one somehow multiplies that part of the widthless line called "four" by another part called "six," then a rectangle is derived as the product, and it has an area of twenty-four—a reality which the line of twenty-four did not possess. And this mathematical process is often supposed to be worthy of translating the physical world for us.

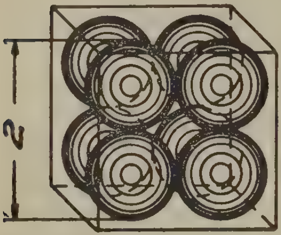

Fig. 6

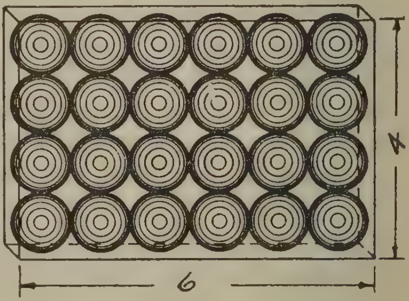

Fig. 7

Does not this inconsistency prove, however, that geometry is inexact; for have we not obtained here different results from two different arrangements of the same parts—or numbered things? Is it reasonable to assert that twenty-four things in a line should have, as a line of "twenty-four" (24), no physical area and then that something real as to area should appear from a mathematical multiplication of the mere numbers which the widthless lines represent? Let us ask him who contends that abstract geometry has validity of its own, independent of real things which are being numbered, how this is.

Again, if the mathematical process does not depend upon physical relationships, what proof is there that it is usable in physics? If geometry has its separate existence, why should its laws and facts coincide with material laws and facts? And yet, if mathematics is altogether an abstract dream-science, we shall not care, nor can we discover, whether it be correct or incorrect—for we can make no physical experiments that will test it. Yet we have discovered that we can interpret the larger facts of material nature with some exactness by the use of the mathematics that we have evolved, and this proves that our theories do coincide in some degree with material nature—but it does not prove that the correspondence is perfect. And reason tells us that, wherever this correspondence fails, the way to error is open.

Coming back to our specific problem, if lines were really widthless—even the number "one" (1) of line, as abstract geometry presupposes—it would be impossible to obtain areas or volumes from a multiplication of lines. The geometrical area is real as to physics (with some degree of accuracy when properly factored) because there actually is this approximate amount of the cross-section of real substance between the designated boundaries—not the total theoretical amount, but a factored percentage of that total. The geometrical formulas receive their reality from physical facts—not the reverse. Yet, at times, we have even been inclined to attribute to the mathematical formulations a measure of mystical validity—some independent function of interpreting (almost of making) truth. At times we have been inclined to discard the commonplace attachment to crude physical facts, and have imaginatively soared too high.

Our abstract calculation of areas is made as though space were continuously solid with matter. For this reason the area of real matter within certain bounds is invariably less than the theoretical amount. It is now important to determine whether the generalized geometrical formulas may be so redeemed by factoring as to make them reasonably dependable in physics. Or has this method its dangerous limitations? Are qualifications to be placed about it? Geometrical formulations give approximately correct results in everyday practices, but are these results ever precisely accurate?

And again, if there is always some percentage of error, does this percentage increase under certain conditions? We question, then, whether the factored geometrical summations give precisely accurate answers; and, if the answers are not absolutely true we wonder whether we can afford to rely upon them as close approximations in all cases.

It may help us here to consider an abstract geometry based on the assumption that space is filled solid with substance—as if there were a continuity of building-blocks fitting snugly together. Then, in order to make use of a number-system, we must assume that this physical continuum is composed of parts, and that all the parts are the same size. With out parts we could not have numbers, and, unless the parts were uniform cubes they could not be packed snugly to form a solid continuum, and the number "one" (1) could not be used indiscriminately to represent the properties of any unit-piece of matter. We postulate a continuum of uniform cubes, therefore; and our number "one" (1) of such a system inevitably refers to the extension, mass, area of cross-section, and volume of this unit-cube. When "one" (1) is used to represent a larger amount of matter it is a generalization.

This assumption of continuous and rectilinear matter, while practically the same as indirectly premised in Euclid, is nevertheless untrue of nature. For this reason a mathematics based upon it is unreal in its gross representations. Let us consider the principles of such a mathematics, however, for we may then better understand how its formulas may be modified by factoring so as to fit approximately (but only approximately) the generalized structures of the physical world—to fit a world, that is, in which the smallest bits of matter appear to be separate spheres of uniform size that constantly move about.

In figure 8, a small section of a solid world of cubes is indicated. Wherever this world is sliced, substance is found, and any volume laid off in it, within whatever boundaries, will be sold with matter. If the extension of one cube is taken as the "one" (1) of length, then a line of "three" (3) will be the extension of three cubes, and the line will actually be composed of three cubes. This line, or row, of cubes is the only possible line that relates to things physical in this universe with this number-system, and this line will have the volume, mass, and number of ''three'' (3). Thus, too, the outlines of a square having sides of length four will inevitably contain within its boundaries a physical area (and volume) equalling that of sixteen of the solid blocks. In such a world the geometrical formula of rectilinear area corresponds with the material reality. If the assumption were true of nature, the geometry would be equally true; but this is so only because the geometrical line, instead of being regarded here as a widthless abstraction, is taken as a row of blocks. On this basis, every volume is derived also, not on the assumption of the multiplication of supposedly widthless lines, but as the result of adding a certain *number* of rows of bulky cubes.[1]

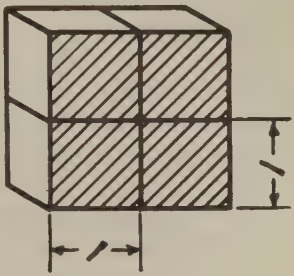

Fig. 8

This geometry, however, is different from the geometry of Euclid in that it frankly gives physical meanings and attributes to all numbers—even to lines that can properly be numbered. It confers extension, volume, and mass to the number ''one'' (1) in a way that Euclid does not definitely profess to do. Yet, until some such concrete reality as this is added to Euclid, it is meaningless as a vehicle for interpreting physical relationships. And if Euclid is to require no factoring to make it applicable to physics, these separate cubes must fit snugly, must be uniform in size, and must each be solid throughout. In such a world, a world of rectilinear dimensions and borders, only those areas would be real physically, or could be obtainable by themselves, which would represent the cross-sections of whole cubes or multiples thereof.

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[1] Nothing can properly bear a number-tag greater than unity unless it is divisible into separate parts. Lines cannot be represented by numbers, and cannot be multiplied one with another in terms of number, unless composed of discrete parts entitled to separate numeration. And the same principle applies to forces, velocities and distances—even to time as it enters physics. If force or distance has no distinct and uniform unit to which the number ''one'' (1) could properly be applied, the statement that force is to be multiplied by distance would be meaningless. The attempt to justify the multiplication of force by distance, while regarding both as continuities, affords proof that the theory of numbers is misconceived. We use numbers as if they were only fit to apply to generalized conditions averaged through space and time, and we thus make our mathematics unreal because inapplicable to that unit event which composes all that is real. The unit event repeated through time and space makes all reality—and this is not the average of all of a series of events consuming extended time and space.

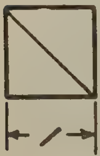

Fig. 8a

In figure 8-a we have imagined a diagonal drawn across the unit square. As the sides of this square represent the "one" (1) of physical extension, and as the diagonal is longer than one side of the square, and yet shorter than the length of two sides; and again, as the diagonal, however generalized, as can readily be proved, never reaches a length which is an even multiple of the unit side, it follows that the length of this diagonal cannot fit into the number-system [wherein the number one (1) is given to the side of the cube] in terms of rational numbers. In geometry, therefore, the length of the diagonal of a square having sides of "one" (1) is found to be the irrational number known as the square root of two. This is the incommensurable which shocked Pythagoras because it was an exception to his philosophy of numbers.

And, if we refer to the two isosceles triangles into which the unit-square is cut by this diagonal, the area of each, obviously, is one-half the area of the unit-square, or one-half of 1, or ½. This fraction is an irrational number for the fraction of the unit of area is itself unreal. A larger square, however, one with sides of length two (2), as in figure 8-b, has an area of four (4), and each of the two triangles formed between the diagonal and sides of such a square will each have an area of two (2). Now, although this area could not be cut out of real matter, because the unit-cubes are indivisible diagonally, this summation of area equalling "two" does fit into the number-system, and does so, not because this triangle is possible in a cubical world, but because this area equals the area of two unit-squares numerically. In a universe composed of tight-fitting cubes we may imagine isosceles triangles,

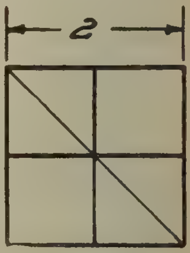

Fig. 8b

and we may formulate such areas abstractly, but, however much we generalize, we can never obtain such a triangle physically.

As to the equilateral triangle, even if we should spread the cubes so they did not touch one another, provided that they were disposed symmetrically, we could not obtain the sides of an equilateral triangle from lines composed of rows of these blocks. An equilateral triangle cannot be drawn through the centres of dots arranged in checker-board formation on a piece of cloth. Trial and error proves this. We perceive, therefore, that the theoretical area enclosed by the borders of an equilateral triangle is unreal in terms of any physically based numerical system in which the unit of number refers to the length of the sides of the cubes. Such areas cannot be composed of whole numbers of matter-blocks, nor be bordered by the contours of such blocks. For this reason the area of an equilateral triangle with sides of two (2) is computed in our rectilinear geometry as one-half the square root of three—an irrational number. We now see what these irrational numbers are (in a physical sense) and we also perceive why our rectilinear mathematics develops irrationalities in the usages which we impose upon it.

No circle, moreover, nor ellipse, parabola, or other curve, can possibly be expressed or measured in terms of the numbers of a rectilinear system. In such a world, curves would be obtainable only by cutting through that which is supposed to be solidly indivisible. And yet we must admit that unless some such solid unit of matter does exist we have no right to make use of a number-system.

Perhaps, however, we wish to consider rows of corpuscles approximating curves. Perhaps we do not care for absolute exactness in some of the larger physical relationships. In such case, even when we cling to the rectilinear system of measurement, even when we continue to suppose that the physical parts of the world are cubical, we may realize that our cubes are extraordinarily small. Thus our other dimensions are very large in relation to the extension of one particle. Under such generalized circumstances, wherein our number "one" (1) does not refer to the true unit of length, but to an extension millions of times as long, we can trace in a row of physical bodies a line which, to inexact inspection, appears to be a continuous curve. This, indeed, is our somewhat careless everyday practice. If our generalization is sufficiently gross the percentage of inaccuracy in the assumption of a continuous curve is not particularly important.

We perceive, therefore, that curves can be treated by the rectilinear number-and-matter system of Euclid, but only inaccurately and as generalizations. Every supposed curve, when examined with a sufficiently powerful microscope, is seen to be a series of separated dots (each with width) which present more or less jagged outlines. This being so, the abstract formula of the curve can never fit the number-system of Euclid exactly; and the findings of Euclid cannot be factored to give exact quantities of physical matter—for, doubtless, the physical dots are not cubes, but spheres, and there is no exact way of measuring spherical attributes in terms of rectangles.

The formulas of Euclid, then, supply us only with rough working rules. This geometry presupposes also that matter remains motionless long enough to be measured and weighed—and this is only approximately true. While many of the large composite bodies are quiet enough as wholes to be regarded as motionless, nevertheless, a closer inspection would disclose the fact that they are constantly radioactive of some of their parts. Not only this, but the parts within the structure oscillate rapidly. The entire mathematics of statics, therefore, is based upon inexact assumptions, upon average conditions only approximately maintained.

Although the quantity of matter within any theoretical volume is but a tiny percentage of that which must be abstractly figured for a true solid, nevertheless the percentage of real matter within any abstract rectilinear volume is approximately the same for different pieces of the same elements (lead, iron, or gold) wherever they may be found,—provided that the conditions of temperature and pressure are identical. Hence, if we forget about radioactivity and about the cyclical motions of the parts, we can assume that the actual area, volume, or mass of this diffuse matter-structure is a fairly consistent fraction of that theoretical amount which would obtain if the world were filled solidly with cubes of this element. The mass of lead, however, is one percentage-factor of the theoretical solid, and the mass of iron another, but these percentages stay practically constant for the same elements under identical conditions of pressure and temperature. This system of factoring the theoretical solid in order to obtain the actuality, is practical, therefore, but only because conditions are dependably similar from place to place.

What, however, if the unit of matter is a sphere rather than a cube? How then does Euclid apply? How far wrong are we sure to be in our attempt to use a rectilinear number-system to interpret a spherical unit—singly or in multiple?

For the sake of simplicity we shall assume that the tiny spheres are motionless and symmetrically placed. This condition of balance, we say, represents the *average* of all the motions in the pressure-pool—the condition that would be revealed by an instantaneous photograph. Thus the air-molecules in the balloon may hammer back and forth from cover to cover without cessation; nevertheless, as a practical matter, whenever we investigate any relatively large amount —say a cubic inch of the interior volume—we shall always discover approximately the same number within it. We can depend upon this as confidently as if the molecules did not move.

However true this may be, in making this assumption we are generalizing again, and our assumption is partly unreal. If, for example, we focussed our microscope on the billionth part of a cubic millemeter of space we should find that we could not rely upon finding any certain amount of air within it during any one-billionth part of the second. Let us admit, then, that the dependability of our assumed condition, its utility as a fairly accurate matter of practice, comes from this averaging of immense quantities through relatively long periods of time in a world which exhibits balanced and symmetrical formations.

Beginning, then, with premises of conditions known to be unreal, let us see how a world composed of separated spherical particles may be measured by a geometry which posits rectilinear areas, volumes, and masses; which uses its whole numbers to represent close-fitting cubes; and which relies upon reaching the physical truths of separated masses from its formulas by a system of factoring.

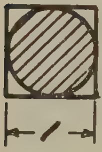

Fig. 9

Figure 9 symbolizes the cross-section of the smallest bit of matter, the tiny, solid sphere, enclosed by a tangential square. The diameter of the sphere is equal to the length of the side of the square, and both, therefore, may be regarded as the "one" (1) of length. In this regard the Euclidean and the spherical concepts of matter coincide. When, however, we consider not length nor extension, but area, we find that the cross-section of the sphere (the circle) is but a fractional part (about 78.54 per cent.) of the Euclidean rectangle (the square) enclosing it tangentially. The area of the square, nevertheless, and not the circular area, is the unit of geometry to which the number "one" (1) conventionally refers.

If, then, the unit of matter *is* spherical, not only will the Euclidean units be incorrect physically, and the number-system improperly applied, but the physical truth will be unobtainable in terms of the system of measurement. A rectilinear area cannot be obtained as an exact multiple of a circular area; nor can the cube be carved out of the indivisible sphere. For exactness, the number "one" (1), if it is to apply to physical nature, should represent the attributes of the rotund corpuscle which, we believe, is the building-block of all material structures, and, when this is done, only exact multiples of the attributes of this smallest bit may be expressed in terms of the number-system thus founded. The rectilinear areas and volumes presupposed by Euclid do not exist, we believe, and their formulas cannot be factored to represent reality exactly.

We adopted our number-system when we knew little about the facts and laws of matter and of its energy. Our concepts were very vague and incomplete. Our unit of number was frankly a misty generalization—a convenient symbol for treating with relatively large groupings. Starting thus, we developed a geometrical system of measurement into which the "one" (1) of the arithmetical system was introduced. And as we adopted a rectilinear system of measurement to symbolize a world which, we believe, is sphere-built, our numbers necessarily referred in geometry to a cubical unit of matter (or its multiples) which, we now believe, do not really exist. Circular areas (the realities) cannot be measured in terms of numbers based on square areas (the abstractions); and it is equally true that the outlines of a square cannot be composed out of physical parts each of which is circular. Our mathematics is irreconcilable with our materialistic truths. It is therefore fortunate that most of our experiences deal with large composite bodies in respect of which the percentage of error in the factored Euclidean formulas are very small. This fact, indeed, has prevented us from realizing our basic error, and has given us an unwarranted confidence in the implications of an erroneous number-system.

I shall illustrate these principles briefly so as to indicate how the percentages of inaccuracy in geometry vary with different conditions.

The basic inaccuracy consists in the attempt to measure spherical matter with cubical units; but this is supplemented by other types of error. The plot of any abstract geometry may not happen to fall symmetrically upon the arrangement of matter-bodies. The theoretical outlines may fail to pass symmetrically between the bits of matter, or they may be situated in a space wherein there does not happen to be any matter at the time. Suppose the abstract outlines pass (in our imagination) through the heart of particles. As the particles cannot be thus sliced, the geometrical suppositions, even though the physical structure is in perfect balance, will indicate either more or less matter than the reality—and the percentage of inaccuracy is apt to increase rapidly as the dimensions become smaller. A third measure of error is introduced by the assumption of Euclid that matter in its unit-structure may be at rest. As already stated, no geometry of statics can ever be more than relatively true. Here again the percentage of error increases as we approach the particularized state.

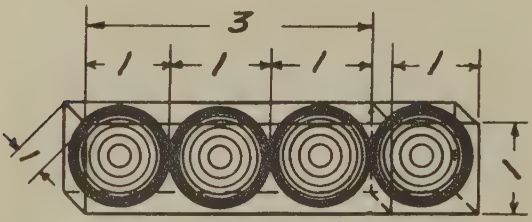

Fig. 10

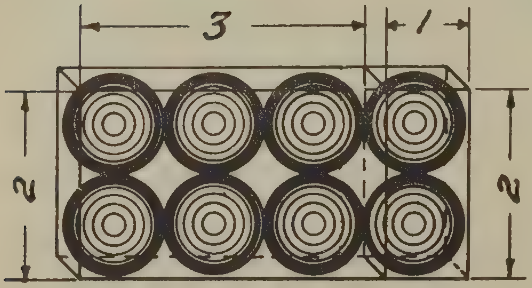

Fig. 11

Figures 10 and 11 illustrate rows of spheres that may be enclosed in a series of uniformly spaced cubes. If we were justified in assuming that these spheres are (as an average) in checker-board formation, there would be a constant percentage of real matter within the rectilinear system enclosing a whole number of corpuscles, and the Euclidean area, volume, or mass could be so factored that the inaccuracy would be no greater than that discovered in respect of the single corpuscle. We have already observed that the area of cross-section of the unit-sphere is not more than about 78.54 per cent. of the area of the square enclosing it tangentially (see fig. 9 page 536), and that it is impossible to express the true area of the circle in terms of areas of squares. If, however, the corpuscles are forced by world-pressures into a more compact formation like that illustrated in figure 12, there would never be, even then, more than 78.54 per cent. of physical area within the unit-square. This percentage grows less as the separation between the corpuscles increases, so that there is no fixed ratio. In a very diffuse arrangement, even a comparatively large unit of area might well be selected which contained no matter.

In the arrangement of figure 12, the percentage of circular or corpuscular area within the square having sides of ''two'' (2) is slightly less than that within the square having sides of ''one'' (1), and there is an even smaller ratio of circular area in the square having sides of ''four'' (4). But this reduction in the percentage of enclosed circular area is not progressive. It increases again as the squares grow larger, and is found to vary very slightly about a mean. However small the contacting circles may be in relation to the size of the square, therefore, so long as these circles are of uniform diameter and fit snugly, the square will enclose an almost uniform percentage of circular area. This fact, too, adds practicability to the generalized Euclidean calculations.

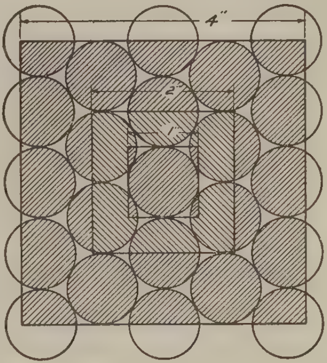

Fig. 12

The arrangement of figure 12 shows parts of solid spherical units within the unit squares. If, however, the corpuscles are indivisible, no such slices, or sections, exist. If we regard the sides of the square as if they were sides of a box into which the solid spheres were to be placed, the maximum amount of corpuscular area will be enclosed by the box when the corpuscles form layers of checker-board formations. That is to say, plane sections of a box with sides of length ''two'' (2) will hold the maximum of four unit corpuscles of diameter ''one'' (1). In every such case of close packing, the plane section of the box will hold a maximum amount of cross section of the spheres of real matter equalling about 78.54 per cent. of the rectilinear area. If, therefore, the spheres are all the same size, and if they fit the rectangles snugly, then, regardless of the relative sizes of sphere and box, an approximately constant percentage of spherical matter may be enclosed in Euclidean space. The same principle is true of spheres that do not touch, provided that they are uniformly spaced. For any amount of average separation the ratio of the real to the abstract is approximately constant. It is only necessary, as the average separation increases, to reduce the value of the factor that discloses approximately the quantity of real matter within the theoretical volume which contains both matter and nothingness.

We may conclude, then, that the percentages of inaccuracy for the factored equations are very slight as regards all the symmetrical formations having dimensions which are exact multiples of the diameter of the unit of matter; and also that they are fairly accurate as regards all the very large areas or volumes wherein the measurements are enormously greater than the true unit of physical length.

In the large generalizations, the percentage of inaccuracy is approximately the same whether or not the large dimensions are exact multiples of the unit. Thus, if the diameter of the unit-sphere is taken as the number "one" (1), and the sides of the box equal one and one-half (1½), the physical area which the box could contain would be considerably less than the theoretical amount. Only one sphere, not one and one-half, could be placed inside the box. If, however, the sides of the box equal one trillion times the diameter of the spheres, the percentage of error of the abstract calculation would be hardly determinable—and certainly would not interfere with the everyday usages of the engineer. In practice, therefore, we are able to use a fairly constant factor-percentage as a means of drawing the physical actualities of mass, area, and volume from the Euclidean computations. We must recognize, nevertheless, that this geometry is an unreal abstraction. It asists us in determining very closely the weight of wheat that a large bin should hold, but our information will not be exact unless we know just how the wheat grains fit into the dimensions of the bin. We must examine the physical actualities. Otherwise there might be an unexpected percentage of empty space, and our answers would be incorrect even though our factors of specific weights were properly chosen. The likelihood of important error will increase as the size of the bin shrinks to the dimensions of a single grain. If we were considering the capacity of a space less in width than the thickness of the single grain, the formula of theoretical wheat-contents would would be grossly inaccurate.

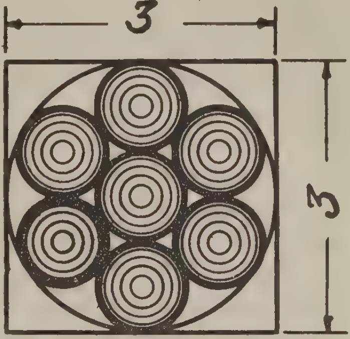

Fig. 13

A square is shown in figure 13 which has sides equalling three unit-diameters — not the true unit, of course, but the unit magnified so as to be visibly represented. The imaginary circle inside this square has the diameter of "three" (3). The circumference of the circle however, imaginary and unphysical as it is, does not trace the outlines of the real material structure, for the unit-spheres within are tangent to this theoretical curve at six points only, and are not bounded continuously by it. The outline of real matter weaves in and out. Yet if our circle has a diameter enormously greater than the diameter of the units of matter packed within it—if the size of the unit corpuscles were perhaps one-billionth-billionth of the size illustrated—then the external boundaries of the tiny, perhaps invisibly small, matter-bodies would approach very closely the symmetrical circumference of the relatively large circle. A very powerful microscope would be required to disclose the fact that the outline was not a regular curve, but that it, too, was weaving in and out—and touching only at points. Whenever we make a tremendous generalization in our number-system, therefore, and attribute the number "three" (3) to a length which is an enormous multiple of the true unit, our Euclidean concept of a curve takes on a workaday utility.

Thus we may deal theoretically and even practically with conditions which the empirical sciences never disclose, and to which abstract mathematics as now constituted will not exactly apply. For the present at least, until our mathematics is renovated and corrected, reason must guide us to an understanding of the realms of the very small, for experience cannot.

Thus far, however, the particular experience rather than general reasoning has been used in almost every case in deriving the mathematical laws to be used in physics. The factor-constant to draw the physical reality from the abstract computation has been obtained by means of repeated tests made as accurately as possible by careful men. In many cases this factor has been found to be almost constant from place to place and under usual conditions. This fortunate fact (due as it is to the presence of an environment with a certain average measure of order—that measure, indeed, which we first "sense" and then formulate) has made our rules of physics useful. Nevertheless, as Professor Leighton tells us: "Causal continuity involves discreteness, creativeness," and the idea of a continuity composed of an endless number of timeless instants or of widthless points assumes the "empirical reality of infinitesimals, which is self-contradictory."

Not the lack of accuracy of Euclid in the everyday method, therefore, but the misconceptions which follow from the acceptance without question of a science which is not *absolutely* exact, are to be lamented. Having applied to the relations of physical things an abstract mathematics which was not developed directly from the attributes of the unit-thing, we have, naturally enough, fallen into philosophical error. We have come to believe, for example, that continuous curves may be composed of static matter, and that continuously curved paths may be taken by the moving matter which is driven by world-forces. Thus we have come to believe that the trajectory of the rifle-ball in vacuum is a true parabola. We believe this because our formulas seem to prove it, and because our observation is too gross to disclose the more exact truth. Because abstract mathematics has been found equal to the task of giving approximately correct interpretations of the more generalized conditions of the physical world, it has come to be one of our most cherished means of arriving at truth. It is often supposed to be absolutely reliable, not only as a mental abstraction, but also as a practical method of interpreting exactly the physical relationships in realms where experience does not conclusively reach. We thus build upon an unsound premise. We establish a number-system which is untrue of the physical unit-fact, and we then use this erroneous system to prove the physical facts.

The error is fundamental—and yet the principles thus erroneously set up are usually accepted as if the foundations of truth. Our philosophy, our reasoning, thus founded, guided, and corrected, is doomed to wrong conclusions. This tree of fallacy must be cut down with vigorous strokes—unsparingly. Its spreading roots are strangling a healthier growth.

Yet only occasionally is our serenity disturbed by the prick of doubt, by the sting of a contradictory fact that cannot readily be brushed aside. Because in some cases at least, we have, by use of a corrective constant, reduced unreality approximately to reality, and because most of our answers are then proved to be close to the actuality, we think that we have proved that the unreal is real. Having reached this stage in fallacy, and arguing from these formulas as if sound, our philosophy of life is of necessity founded partly on untruth. This misconception will remain until we retrace our thoughts, and undertake a new beginning with a new understanding. We must set up a criterion more appropriate than our present-day mathematics for the material world and its mechanical relations and experiences.

I shall not discuss the inaccuracies of geometry further. One would require more than a volume to do justice to this subject alone. Nor shall I devote many pages to illustrate the misconceptions in higher mathematics. I shall outline but a few more of the inaccuracies which breed incorrect conclusions in physics. The conventional mathematics is so unsound in its fundamental construction that one may assert that all conclusions derived *exactly* from it are thus proved imperfect. It should be an axiom of philosophy that a physical theory *cannot be correct* if it conforms exactly to the computations of our abstract mathematical science. For example, since the calculus proves theoretically that the orbit of a planet may, from the power of gravitation alone, be drawn into an absolutely perfect ellipse, I should say that this proof really signifies that it *cannot* be so. Indeed, I believe that in this case the theory is not even approximately correct.

In trigonometry, continuous physical reality is assumed to fill space in every direction. It is supposed, too, that however one may take his choice of slices from this solidity the fancied physical arrangement will appear. Dream of any physical outline, or of any solid shape, and here it is to be found in matter perfectly traced or spaced or angled, just as you imagined it. How accommodating is the physical world to our abounding fancies! The physical possibilities are supposedly unlimited. In whatever direction we gaze or move the materialistic facts have been assumed to keep pace with the mental imaginings.

Thus it has been assumed that an infinite number of direction-lines may project from a focal point. Indeed, for trigonometry to be true in physics there must be an infinite number of solid piers of matter under each of the infinite direction-lines, so that wherever one saws off the bridge the end will rest square on a substantial support. Also there must be an infinite number of possible angles between the infinite number of radiating rows of things. Trigonometry, like geometry, takes for granted a solid and uniform continuum; and we need proceed no further to realize that this science does not subscribe to physical facts.

Conic sections, the mathematics developed by Descartes, displays the same unreality that pervades trigonometry and algebra. The cone, of which the conic section is a slice, however large its measurements, is assumed to be homogeneous throughout. One would almost think from studying this mathematics that the smallest unit of matter must itself be a cone, and that these tiny cones are fitted together to make other cones—larger but solid. Unless this were the case, unless every cone were solidly homogeneous, how can one imagine that a horizontal slice through any of these tapered bodies standing upright will invariably, or ever, supply a continuous physical circle? The formulas, too, which represent these theoretical curves are supposed to be exactly applicable to physics. Inside these circumferences there are supposed to be uninterrupted physical areas. The erroneous concept of the uniform continuum is accepted in conic sections just as it is in geometry. Thus the formula of the circle (x^2 plus y^2 equals r^2), which implies that every point of the imaginary circumference may be reached by the imaginary radius (r), contains the same type of reality. The formula posits a continuity of uniform points (either all matter, or all emptiness) in the abstract curve of which it treats. Obviously, this principle, unreal certainly in its physical aspects, cannot be used with assurance in dealing with material relationships. Nor does its utility prove that there is ever a real curve of solids, or a uniform curve of anything.

I am here obliged to differ in fundamental theory from even so broad-minded a thinker as Dr. R. A. Millikan, when, in the Terry lectures at Yale University, he said:—

> For the exact and obvious truth is that no discovery of the twentieth century has thus far subtracted, nor can it ever subtract, one whit from the great body of *experimental facts* brought to light in the nineteenth century.[1]

Even these generalized experiences, I insist, have contained tiny percentages of error-ratios, so small indeed as to be almost negligible in common usages, but real nevertheless. Dr. Millikan says that "Experimental science never has taken and never can take a backward step. It moves only forward in ever-expanding circles." On the contrary, the data of science, as brought forward from the nineteenth century, can be made exactly true only by a revision of formula and principle—by an elimination of some things heretofore inserted as if exact truth. If the word "true" is to be taken literally, I must also disagree with Dr. Millikan's statements that "Finally the principle of the Conservation of momentum and the laws of electro-dynamics are still true in all large-scale phenomena such as alone we dealt with up to 1900,"[2] and again, that "For the practical purposes of our present workaday world it [Conservation] is completely true." How can one still think that Conservation is "the eternal truth for the fields which called for its formulation"?[1] (Professor Eddington refers to Conservation as a "truism.") These statements of Dr. Millikan, moreover, do not seem consistent with his earlier remarks that "the very foundation of mechanics, when looked at microscopically, are unsound, that apparently all periodic motions are resolvable into circular and linear co-ordinates which cannot progress continuously as demanded by Newtonian laws."[2] It seems to me that Conservation and the mechanical laws are partly untrue—even as wholes. Yet I can agree quite unqualifiedly with Dr. Millikan when he says that "the childish mechanical conceptions of the nineteenth century are now grossly inadequate."[3]

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[1] R. A. Millikan: *Evolution in Science and Religion.* Yale University Press, p. 50.

[2] *Ibid.*, p. 52.

Of all the departures from reality, however, probably none is so nakedly exposed as that of the calculus. This science, one must almost think, was constructed frankly as an inaccurate generalization. The particular, the unit-event, was deliberately discarded—thrown away as if worth nothing. The building-block of the physical happening, the smallest influence of the event in question, was dropped from the formula, and that which remained was supposed to be usable exactly in all cases—even for translating occurrences involving the unit-event in important or in controlling relationships. How extraordinary this reasoning was, and still is! At first the smallest happening is deliberately scorned, and ejected, and then later the formula, thus mutilated, is used to interpret, not only the generalized physical occurrences compounded of similar smallest events acting cumulatively, but even those occurrences wherein the influence of the unit-event is of first importance.

In the calculus the assumption was made that the physical event can be of such smallness, so close to zero in effect, as to be negligible. It is built on the unreal premise of continuity in mechanical event. Yet, if matter is composed of granules, all composite physical events are built of these smaller influences—and the unit composing these truths cannot be made larger or smaller by the imagination alone and still retain its ability to interpret reality. By such methods, basic correctness is sure to be sacrificed.

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[1] *Ibid.*, p. 52.
[2] *Ibid.*, p. 26.
[3] *Ibid.*, p. 27.

As already stated, cumulative events and non-events may be approximately averaged, but there is no exactness in this averaging method unless every condition is appropriate for it. The larger the generalization the easier it is to approach accuracy. Thus the weight of the solid matter in a cubic foot of space composed of vacuum and matter may be stated with almost perfect accuracy as a percentage of the whole. The error in the use of the percentage-factor is most striking only when we select some tiny volume which is not a mixture, but which, if sufficiently small, will be either all matter or all emptiness. In such event, or in close approaches to this state of affairs, the truth cannot be even approximated by use of the formula of averages.

In philosophical interpretations also, or in efforts to explain the more minute occurrences, or when judging of facts at those times in such perfect balance that the force of the minute event controls the situation, the formula which has excluded the separated tiniest influences is seen to be inadequate. The calculus is such a science. So practical has it proved to be in our usual gross experiences, nevertheless, that even though found to be inappropriate for certain occasions, it is now used with the conviction that in the larger relationships its answers reflect the accomplishments of universal and undeviating laws, and that these answers are so true, so exactly correct, that we may regard them almost as heavenly gifts of principle. So flawless is the calculus usually supposed to be as a means of interpreting mechanical truth, and in its application to the larger problems of the physical world as well, that many are ready to agree with Emanuel Kant that it is an *a priori* mental concept.

Our view is different. Because the calculus excludes quantities from its formulas which in most cases are even larger than the smallest unit-event, we see that these amputated formulas cannot relate to the particularized situation in which the unit-occurrence takes a prominent part. They cannot measure the single piers of matter which at intervals support the stretched mental bridge. It is obvious that if all dimensions shorter than a foot are left out of his formula as unworthy of notice, the engineer cannot possibly compute with it the measurements of a tiny pier one-half inch wide, let us say, which supports a span of seven inches. Nor can he measure one entire span exactly. Only when he considers several spans will his formula become useful; and even then it will not be exact. Nor can the true dimensions of any relatively large object be determined with complete exactness with an instrument which does not reveal the tiny details.

The calculus is too gross for accurate formulations. The continuity which it presupposes does not exist except to the gross view. Indeed, if there really was such a continuity, the number-system could not apply to it. If the user of it does not understand exactly what his formula represents, if he does not realize its limitations, and if he does not recognize that its application to physics imposes inaccuracies, he will assuredly be led into philosophical error. He will come to think that his formula is universally usable, and that every answer which it gives is exactly true—that continuities are actual. Usually the mathematician does not hesitate to use the calculus to interpret a condition which, according to theory, must come into a state of such exact balance that the unit-event (the part omitted from the formula) will play the decisive part—where the final tiniest straw, by its placing, as we contended when discussing Mr. Russell's theory, will make the huge tower fall this way or that.

It is this tiniest of blows, also, this unit of force, which bit by bit deflects the otherwise straight-line motion of a bullet through what seems to be empty space into what we call a parabolic curve. Wherever force is exerted, it is the blow of this grain of matter, repeated at intervals, which creates the entire effect,—the deflection of the straight-line motion, or the reversal of direction. It alone is important, so that we cannot expect to obtain exactly correct answers in dynamics from a mathematical system which fails to note the particularized impulse and its effect.

If instruments ever become so perfect that the details of the smallest event may be examined, we shall surely perceive that the conclusions of our generalized mathematics and experiences do not agree precisely with the facts. The usual error of experience has both philosophical and mechanical import, but the effect of the error on philosophy is more important in some cases than in others. There is no great harm, perhaps, in postulating a true curve for conditions wherein the granular influences are really deflecting the bodies into the paths of polygons with the tiniest of sides, since the difference between the postulate and the truth is indetectible, and the percentage of error, mechanically speaking, is not very important in everyday physics. It is important, however, from the standpoint of theory and fact that we should not conclude erroneously that the tower will crash this way rather than that. Nor should we be led to think that it will be likely to fall at a time when the balance of the repeating and tiny forces should cause it to stand upright indefinitely. And if it should fall when the accepted definitions of matter and its energy tell us that it should remain standing in perfect balance, we must, if we are to confirm our theories, disclose the hidden influence which makes it topple. Not only must this be done, but the presence of this hidden force must harmonize with our general theory. Also, our formula must include this minute influence.

Where the decisive happenings are too gross to reveal the final, controlling influence, we must reason the problem through; we must conceive a mentally reasonable theory. The tower stands there balanced, and the influences which tend to sway it this way or that through any unit of time are too minute for us to measure them, or perhaps even to realize them. How, then, with our inexact knowledge, and with our incorrect theory, do we explain the balance of the tower? Sometimes, I fear, we adjust our mathematical formulas and ideas so as to make them conform with the facts. Indeed, we have omitted so much from the formulas of the calculus, and the units of measurement which remain are so wide-stretched, that we are permitted no little latitude in our interpretations. The broad face of the hammer gives the same results whether the nail-head is struck exactly on its centre or to the right or left of the centre. If it suits our theory better we can suppose that the inner part of the face of the hammer is hitting the nail at a time when a truer theory would be sure that it was the outer edge. Thus we can often adjust the mathematics to fit the reality without exceeding the limits of the exactness of our formulas. Lacking exact knowledge, we can adjust our ideas of the hammer-face to make it seem to correspond both to an incorrect theory and to a correct result.

Let us suppose that we are measuring two intermittent and opposed forces of value 25 operating at equal intervals, by means of a formula which has discarded all influences measuring less than 10. Obviously we shall be unable to distinguish between forces ranging from 20 to 30, for we recognize no stopping-places between them. The forces balance each other, however, so we naturally must assume that both are 20 or that both are 30. And since, so far as we are concerned, either 20 or 30 is correct, we shall finally choose the figure that seems to conform best with the facts. Thus we may reach a conclusion that fits with the reality, and, at the same time, confirm an incorrect mathematics and an incorrect assumption.

If the two forces which we observe are really balanced hour after hour, it makes no particular difference, I say, if we regard them both as 20's or as 30's. Suppose, however, that the opposed forces are not composed each of a single unit, but that two discontinuous forces of 19 and 7 respectively act on one side during the same total elapsed time used by a force of 26 acting in opposition. We cannot realize the presence of the force of 7, for our instruments do not detect it, and its value is omitted from our formulas. Nevertheless, the state of balance which we can detect is being maintained supposedly by the two forces of which we are grossly aware, and it is our problem to explain this balance in accordance with our formulas and in harmony with our preconceived theory. Our theory, also, denies the reality of forces measuring less than 10, and yet, in this case, except for the force of 7, there would be no balance. We can easily adjust our generalized mathematics to fit this reality, and thus to explain events in terms of an incorrect opinion of phenomena. We can assert that the force of 26 is 20, and that the force of 19 is 20. This leaves us in the logical position of denying the reality of the force of 7 altogether. This is very satisfying, for we were quite sure that there was no such force present, and now our mathematics, by giving us the balance without it, apparently disproves its reality.

We shall probably continue to be satisfied with this proof until some day experiences with the tiniest bits of matter (experiences made possible by greater refinement in our scientific instruments), reveal that, in just such a condition as this, there is an oscillatory movement that would not be present if there were only the force acting in one direction which perfectly balances one impulse in the opposite direction. Within the atom, in particularized conditions where the effect of influence is more readily disclosed, actions are revealed which seem to contradict accepted theories and mathematical principles. Confronted by this mystery, we ask whether that which happens within the atom may not be so alien that its principles do not reach outside into the universal spaces? Is it not possible that mechanical principles may be divided into two classes? May we not retain our old ideas and formulas in the wide reaches while we surrender them elsewhere? Is the calculus still applicable to the motions of the planets about the sun at a time when it fails utterly to explain the motions of the electrons about the nucleus of the atom? Or has the time come to revise both our mathematics and our fundamental theories so as to make them harmonize with all experiences?

In this dilemma, many physicists still satisfied with the logic of their mathematical concepts have not attempted to alter their formulas for use in the large relationships. Strangely enough, they still think that their science is sound in the wider fields. They may be convinced, nevertheless, that for some mysterious reason the Newtonian principles do not apply exactly within the atom. Undeniable experiences with the smallest particles prove this. This troubles the physicists, yet in most of the text-books the old generalized mathematics are still described as unalterable principles of truth for the relationships of the broad universe. The broad aspects, it is still claimed, must still harmonize with the findings of the calculus. This is not a dangerous contention, for our generalized mathematics, with its stretched units and its indirect assumptions, can readily be adjusted to suit the facts in those situations of balance where the gross result alone is noticed, and where the character of the details causing this result may still be so glossed over as to subscribe to some preconceived theory of force-manifestations. In the large relationships, two separate and distinct influences of 19 and 7, if it suits our fancy better, can still be regarded as one force of 20 only, and no one can prove us wrong by experimental evidence. In reference to the larger relationships, therefore, our old theories are retained practically unaltered by modern knowledge.

Thus we have concluded erroneously that some force-relationships of the physical world are continuous. The formulas of dynamics are arranged, indeed, on the assumption that the limited force of gravitation is continuous. It is supposed that falling body curves continuously, and that they accelerate unceasingly. The true unit—the intermittent, the limited and granular influence of the blow of the smallest physical bit—is left out of the formula involving force; and a generalized unit, a large multiple of the true unit, is used. The formula inevitably represents, therefore, a bridge-like continuum,—a bridge of force, indeed, which extends far enough for us to perceive its reality. The stretched bridge is realized at the time that the existence of the tiny and granular forces which intermittently compose the whole is denied.

The force-delivery, the motion, the acceleration, are improperly perceived and computed as wholes, and not as parts. The streak of the pencil across the page is a line—not a series of separate dots. The truth, as we have said, was not understood in the days when the formulas were adopted. Since, however, the formulas of the calculus exclude from consideration all the shorter distances which, unit by unit, consist of piers of force and gaps of nothingness, (accelerations here followed by uniform motions there), we have incorrectly accepted the idea of continuous force and acceleration. Indeed, the successful use of this mathematics (except where the atomic relationships, the edges of electrons, are reached) has convinced many that these assumptions are sound; but this success in general practices, as we now see, is not the sort of proof we require. The calculus is untrue; but it is easy to understand why, having accepted it as perfect, we have been able to prove unreal concepts true by it.

It is easy for this mathematics to lead us into wrong beliefs when the situation is so balanced that the grain of influence sways it decisively. Let me illustrate: It is proved by the calculus that the orbit of the earth may be elliptical although acted upon only by the attraction of the sun. It is supposed that the earth may come constantly closer and constantly faster towards the perihelion point while constantly attaining the direction, distance, and velocity which should permit it to move in a circular path; and then it is believed that the earth leaves this perihelion point (this point where this balanced combination of attributes tending towards circularity is attained) possessed of tendencies to move farther away, slower, and at that more obtuse angle to the radius vector that permits the curve of an ellipse. Thus, through this false idea of continuity, through this smudging of the material realities, and through an incorrect mathematics of continuity which omits the important granular influences, it may be proved that the earth passes through the point of exact balance and equilibrium of forces and directions without ever succumbing in the least to the balancing influences. Yet, in other mechanical situations we realize that, through time, balancing influences finally arrive at the state of balance.

A different mathematics, one which made a record of the fact that the forces of gravitation are discontinuous, and showed wherein the granular influences were defined, would disclose the exact tendencies at the perihelion point, and would reach a different conclusion. So perfect is the state of balance of forces and directions at the perihelion point that a proper mathematics would prove that the tendency to later retardation would not obtain. There would finally be no average tendency for the earth to leave or approach the sun, but she would move onward from the perihelion point, not in an oval path with varying velocities, but in the path of a regular polygon (approximately a circle), with a uniform velocity, and with the sun as the mean centre of motion.

The earth, of course, does not move in such a symmetrical path about the sun; but, if mathematics applied more exactly to physics, if the calculus had not discarded the influence of the unit-event, I am convinced that scientists would be obliged to seek some exterior source of power now to account for her continued deflecting motion and for the repeating oval (really unsymmetrical) path. The actual happening, the lack of balance that does obtain, is explained, I am convinced, according to an incorrect theory, and according to an equally inexact mathematics. Were it not that scientists have been fairly satisfied with their explanations of physical events they would have been obliged in many cases to develop a different philosophy of causes.

It has been unfortunate that in so many cases this sort of mathematics has appeared to interpret the mechanical situation adequately. Until recently it has seemed to explain many phenomena so satisfactorily that the mathematician has regarded his explanations of them as certainly sound, his definitions and concepts as undoubtedly true, and his knowledge as incontestable in certain respects. Gross experiences still seem to prove this to him. And he usually puts into a different category the conflicting experiences within the atom, hence he is able to remain satisfied with his formulas even when he knows that certain small influences have been ignored in them. Yet there is much truth in the point of view of the philosophizing father of Tristram Shandy that "error was error,—no matter where it fell,—whether in a fraction,—or a pound,—'twas alike fatal to truth, and she was kept down at the bottom of her well, as inevitably by a mistake in the dust of a butterfly's wing,—as in the disk of the sun, the moon, and all the stars of heaven put together." Tristram said that his father would assert "that it was for want of considering this properly and of applying it skilfully to civil matters, as well as to speculative truths, that so many things in this world were out of joint."[1]

I shall now summarize the routine we have followed in arriving at our erroneous conclusions. First, the influence of the particularity has been omitted from the dynamic formulas of the calculus. Then an averaging generalization has been accepted which postulates the unreality that continuity (or infinity), when multiplied by a percentage-factor, will equal discontinuity (or finiteness). The formulas thus derived have then been used to interpret the relationships of separated matter-bodies affected by intermittent impulses. Naturally enough, they have proved that a body may be deflected by the supposedly continuous force of gravity alone into a perfect curve. Untruth has thus been proved true. But when this mathematics is corrected to correspond with the physical reality, and with the actuality of finite and therefore discontinuous force (whether gravitation or any other force), the inverse square law of gravitation will be found inadequate as an explanation of oval planetary, as well as of electronic, orbits, and a philosophy which otherwise accounts for the approximately oval paths may have some chance of proving acceptable.

To show that I have not exaggerated in my description of the error underlying the calculus, I shall quote principles as commonly set out in text-books.

Professor F. L. Griffin writes that "By the 'area' of a plane figure bounded by a curved line we mean the *limiting value* approached by the area of an inscribed polygon, as the number of sides is indefinitely increased, each side being indefinitely shortened."[2] The mathematician assumes that these "indefinite shortenings" might easily be possible, even though the physical universe in reference to which the mathematics is to be used is perhaps composed of discrete particles with definite lengths and distances of separation that cannot be altered by an act of imagination. Professor Griffin says, also, when speaking of the direction in which a curve is pointing at a certain place, that "The instantaneous direction of motion is simply the *limiting direction* of the secant, as the time-interval is indefinitely shortened." [1]

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[1] Laurence Sterne: *The Life and Opinions of Tristram Shandy,* Book II, Chap. 19.

[2] F. L. Griffin: *Introduction to Mathematical Analysis,* p. 64.

Now the path to which Professor Griffin should refer, whether it is made by force, or whether it represents points at rest, is not a true curve in the sense of being continuously deflected. It is a polygon, and only the approximation of a curve. If the figure is made by motion, the movements which produce the polygon are directed from one corner of it to the other. These motions from point to point are in straight lines, and their directions are changed instantaneously. Between the instants during which these immediate changes of direction occur—that is to say, between corners of the polygon—there is no deflection. The formula of Professor Griffin which is supposed to arrive at an indefinite number of "instantaneous directions of motion" is therefore incompatible with the physical facts. The same criticism is true of curves supposedly made up of motionless and separated particles. There is no continuity of deflection, and the light-lines (the shortest paths) run straight from corner to corner of the polygon. If one is not very careful, some of these imagined secants will be so unreal as to miss these corner points altogether. It is readily seen, then, that the idea of the "limiting directions" of curves is inappropriate for use in physics except as a generalization. It is only appropriate for a uniform continuum of physical line, something that does not reach very far in any direction in this dualistic world.

As to accelerations of moving bodies, we may quote from Professor Byerly of Harvard University to see how the calculus is applied. He tells us that "The *actual velocity* of a moving body at any instant, is the *limit* which the body's *mean velocity during the period* immediately succeeding the instant in question approaches as the length of the period is indefinitely decreased." [2]

Here is an affirmation, which, unproved in the physical world, depends for its utility in translating material relationships entirely upon the nature of the physical facts. If matter is indeed composed of discrete particles, and if momentum is delivered at intervals, this principle assumed in the calculus may be quite inappropriate. The assumption that acceleration is continuous would not be true, for example, of a sailboat starting out before the wind; for the air-particles strike the sail discontinuously, and between these separate blows there is no increase in speed. Again, if the motion delivered by each separate air-particle is received instantly, the boat, while gathering headway, will be going first at one speed, and then, on receipt of the next blow, will be moving immediately at a speed which is greater, not by an infinitesimal, but by a specific amount. How can the speed of the boat be altered during each billionth part of a second if the air-molecules do not strike this often? If nothing happens to the motion during each billionth part of a second, but only every thousandth part, the assumption that the speed is increased during every infinitesimally small time-interval is erroneous, and a mathematics based thereon will not be correct for use in physics. Indeed, if the theory of limits is to be unlimitedly applicable to the motions of physical bodies, the forces which cause accelerations *must* be continuous.

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[1] *Ibid.*, p. 65.

[2] W. E. Byerly: *Differential Calculus*, p. 6.

The particular experience, as even now observed by our most delicate instruments, supports the philosophy of discontinuity. By the use of high-powered microscopes, we have learned from the phenomenon known as the ''Brownian movement'' (referred to in the Introduction) that the pressure against tiny matter-bodies which holds them down against the earth is intermittent. Every once in a while the tiny bodies hop as if in opposition to gravity. Thus visible *practice* demonstrates with the smaller bodies that gravity lacks the ability to hold a body continuously compressed against the earth. If our microscopes were small enough to distinguish single quanta of matter (if I may use this term), we should doubtless see them leaving and returning to the earth at enormous speeds, first in direct opposition to gravitational impulses and then back again. Some may even leave the earth-environment permanently. These same microscopes would show other larger composite bodies in balanced formation which retain their general structures day after day, and which remain day after day squeezed as wholes against the earth; yet even these large bodies would be released at times from gravitational force to such an extent that parts of them (and at longer intervals even the wholes) will leave the earth entirely for an instant. The parts of a structure and the structure as a whole, then, are really vibrating up and down as the force of gravity first acts and then lapses, and then acts and lapses again—and really lapses longer than it acts. The microscope—itself relatively gross—here tells us the opposite of that which the calculus assumes. Observation tells us that the theory of limits applies to physics as a coarse generalization only, and that calculus is inappropriate in a philosophic interpretation of nature, and useless for disclosing unit-relationships.

In one of his later definitions, Professor Byerly states the philosophy of the calculus very plainly, as follows: "An *infinitesimal* or *infinitely small* quantity is a *variable which is supposed to decrease indefinitely;* in other words, it is *a variable which approaches the limit zero.* What we have called the *increment* of a variable has, in every case considered, been such a quantity; and what we have called a *derivative* has been the limit of the ratio of infinitesimal increments of function and variable."[1] Need more be said to prove that the calculus is inappropriate for exactly defining the facts of the physical world?

As Comte has said, "The notion of infinitely small quantities is a false idea of which it is, in fact, impossible to obtain a clear conception, however much we may deceive ourselves in the matter." When the idea of the calculus was introduced, says Bledsoe, "on all sides there rose objections from the common-sense and reason of mankind."

The reader who is interested in obtaining the concepts of the calculus will obtain the modern theory very simply in *Calculas Made Easy,* by Professor Sylvanus P. Thompson. On page eight, the author excuses the discarding of the small quantities from the equations of calculus. He suggests that while an ox might worry about a flea of ordinary size on his back he would probably not trouble himself much about the flea's flea. Quite true—unless the ox were interested in the philosophy of fleas and in the effect of the flea's personality. If he is content to regard the universe with his dull bovine eyes which take in only gross generalizations, and if he does not care to analyze particulars closely in order that he may reach a more exact understanding of life, then his course is proper enough, and his neglect of the smaller events is even sensible. Other ox-like persons may also forget about the smaller fleas. Nevertheless, the interpretations of universal events thus made will be unacceptable, for the principles have not been established by an accurate mathematics.

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[1] *Ibid.,* p. 149.

I shall now end this discussion. It has been necessary to point out the basic error in much of our mathematical interpretation, for what true philosophy could ever stand uncriticized, or escape ridicule, if it were admitted that our usual present-day mathematicians are to give the final verdict based dogmatically upon their formulations? If the members of this tribunal (a group which for the most part regard this fallacious series of generalizations as if they revealed infallible and particular truths about nature) were admitted to be the proper judges of philosophic truths, surely one could expect only disapproval of any truly reasonable philosophy. The judges would repeat "wrong, wrong," as the discouraged philosophers offered one after another those deductions which seem rational to them. We can no longer permit the philosopher to surrender his concepts merely because the physicists turn their thumbs down to every reasoned belief that the old formulas will not confirm!

Amiel puts the case for the philosopher strongly, thus: "Science is a lucid madness occupied in tabulating its own necessary hallucinations. The philosopher laughs, for he alone escapes being duped, while he sees other men the victims of persistent illusions."[1]

Up to approximately the end of the nineteenth century, the physicist, characteristically, was dogmatic. He was sure that his principles were unfailing, everlasting. He scorned the doubter. His rules encountered no exceptions—and his theories seemed to be proved sound by innumerable checkings, and by many types of experiments. In 1895, however, the discovery of the X-ray introduced an unexplainable novelty. For the first time in several centuries a principle outside of classic physics was revealed—a new phenomenon, which could not be measured by the old formulistic method—and, as Dr. Millikan says, "*. . . we all began to see that the nineteenth century physicists had taken themselves a little too seriously, that we had not come quite as near sounding the depths of the universe, even in the matter of fundamental physical principles, as we thought we had.*"[1]

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[1] H. F. Amiel: *Le Journal Intime,* trans. by Mrs. Humphrey Ward, Vol. I, p. 308.

After Roentgen's discovery, came other knowledge demoralizing to mechanical tradition. The electron theory of matter quickly followed the X-ray; and then the knowledge came of a radioactivity of matter possessing a tremendous energy derived without a known cause. This was a shock to conventional belief. Radioactivity, too, proved the fact of the transmutability of the elements—a doctrine quite contrary to the firm opinion of earlier days. But now the modern physicist is asked to believe with Einstein something that even further conflicts with this early belief—namely, that mass and energy are interchangeable, and, therefore, that the quantity of matter is not fixed.

In this dilemma, Dr. Millikan asks a necessary question: ". . . where is now the nineteenth century physics of the ether?" He concludes that "the physics of the ether is not a vague set of ideas, but that it deals with sharply measurable experimental facts, the validity of which is questioned, and which are completely independent of all speculations and theories."[2] Up to 1900, the theory of ether waves had never failed, but "during the first fifteen years of this century there was discovered a group of new phenomena which baffled explanation in terms of nineteenth century ether physics."[3]

It seems that principles contradictory to Conservation, and to physical science in general, and inappropriate for the conventional mathematical formulas, are at last being discovered in the relationships of tiny bodies where gross generalizations do not serve. Evolution, and the Power creating it, introduce phenomena into mechanics which are most puzzling to the Conservationists, and which even the most modern of typical physicists cannot explain. Yet these events which are so utterly mysterious, and so little to be defined in harmony with conventional beliefs, become almost self-evident commonplaces as soon as one alters his view.

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[1] Dr. R. A. Millikan: *Evolution in Science and Religion,* p. 11.
[2] *Ibid.,* p. 20.
[3] *Ibid.,* p. 21.

The ether concept presents great difficulties to the modern Conservationist. He cannot support it yet he cannot abandon it. It suffices for many phenomena which are otherwise incomprehensible to him, and still other events cannot be explained if the ether wave-theory be true. In the words of Dr. Millikan, "*We can at present make no mechanical picture whatever of the act by which an ether wave is born and started out on its journey through space.*"[1]

Many phenomena which nineteenth century physicists deemed to be continuous in structure have recently been proved to be granular. This discovery is most upsetting, since it calls for a complete change in the physicist's point of view—for a re-ordering of thought which he cannot well make. He can hardly surrender all of his old beliefs. He would be left almost bare, for he has adopted no new theory which will serve. The old hypotheses, while evidently riddled with error, are still held to. The formulas seem to work in most cases, although based on fallacy. If correct results are to be derived from hypotheses proved fundamentally unsound by both experience and reason, what shall be done during the interval when no sounder theory has been offered?

The physicists must do as they are doing until they acquire a truer insight. They use the theory which works best in the particular case, regardless of the fact that the theories in two different cases are completely opposed. Some are frankly admitting their difficulties—although most of them still believe that their old truths are absolutely true so long as they are applied to the generalizations of the old days.

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[1] *Ibid.*, pp. 24–25.

They fail to see that even their old physics contains fundamental error in all cases.

The physicist has learned since 1900 that even an electrostatic charge has a granular structure. He accepts the new datum, for it has been proved beyond question; but he has not yet changed his generalized formulas of ordinary physics to suit his new knowledge; nor has he revised his mathematics for closer correspondence with physical facts. His mathematical formulations still presuppose continuity of matter and of force in realms where this concept is erroneous and to which mathematics would not apply. No one has stated the inadequacy of the old science more honestly than Dr. Millikan:—

> We have at present no one consistent scheme of interpretation of physical phenomena, and we have become wise enough to see, and to admit, that we have none. We use the wave theory, for example, where it works, we use the quantum theory where it works, and we try to bridge the gap between the two apparently contradictory theories, in a purely formal fashion, by what we call the correspondence principle. *It is true that we are slowly learning more* of the rules of nature's game . . . but the day has gone by when any physicist thinks that he understands the foundations of the physical universe as we thought we understood them in the nineteenth century.[1]

The day must come when the physicists shall build on new foundations, on foundations which include neither the Conservation of mass nor of energy, nor of the two combined. Even Einstein, who tries to help by connecting mass (M) and energy (E) with the speed of light (C) in the formula, MC^2 equals E, does not revise science adequately. Mathematical propositions must be revised to make them applicable to a world of granular matter and of granular energy. Not only this, but mechanics requires the acknowledgment of a constantly active and effective outside Cause of cyclical motions, and of an "absolute" Accomplishment by this motion.

The more broad minded of the scientific mathematicians fully recognize the truth of the foregoing criticism of mathematics. Such men as Poincaré and Euler have admitted that they value mathematical equations chiefly for the possibility of arriving at valuable and otherwise unreachable conclusions through these short-cut methods. In confirmation I shall again quote from Mr. d'Abro's book,[1] for no one seems to have combined a broader and more rational scientific view with the ability to make singularly clear statements. In some places, however, he seems to be inclined to accept the mathematical deductions as of more than justified validity. The deductions, of course, must share the incorrectness involved in the method.

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[1] *Ibid.*, p. 27.

In proving his assertion that mathematics is justified because for unknown reasons it does lead often to otherwise undiscoverable principles of value, Mr. d'Abro writes that, when Euler appealed to imaginary magnitudes and ''irrational'' numbers, he was able to reveal ''an unsuspected relationship between what were widely different types of functions.'' (p. 409) Not only this, ''but the two numbers . . . taken from totally different regions of mathematics, from geometry and from logarithms, are suddenly found to manifest extraordinary relationships. But this introduction of imaginary numbers into mathematical analysis was soon to lead to still more wonderful discoveries'' (pp. 409–10). Yet, as he says, ''It is of course obvious that the mathematician is not primarily interested in knowing whether his abstract speculations have any counterpart in the real objective world. . . . The sole object of his investigations is to explore all rational possibilities and to co-ordinate into one consistent whole various mathematical edifices which at first blush might appear to be totally estranged from one another.'' (p. 411)

Our criticism of the mathematical method rests upon the ground that a rational co-ordination has not been made. This is fully evidenced by the fact that the physical concepts are now extraordinarily confused. Obviously, mathematics has been misapplied. In its treatment of physics it has been used with faulty judgment.

Mr. d'Abro says that the procedure of mathematics, as well as of theoretical physics, has been involved in "the search for unity through progressive generalisation." And he again says "Mathematics deals with generalities. It seeks to obtain general laws and general theories as opposed to particular results." (p. 405) This is the weakness of the method, for these theories of the general, even if approximately true, are unfortunately not compatible with the facts of the particular. Yet, the property of the smallest bit is the basic reality of physics. Only repetitions of the unit properties at regular or irregular intervals in space and time distinguish between the effects of the particular and the composite—and these intervals are not parts of the mechanical definition, for they are not attributes of matter. Mr. d'Abro asserts, however, that "we must recognize that substance escapes us completely; all we can hope to approach is structure or relationship." How can he say this when the structural (or composite) effect is made real by the repetitions of the attribute of solid inertia possessed only by the unit of substance? And knowledge of the truth of the structural relationships, even if attained, does not satisfy the philosopher. Nor can the entire truth of structural relationship ever be exactly identified without the use of knowledge superior to that which this mathematical sense-data-method can reveal. Exact knowledge of the composite relationships and of the edges external and internal is impossible until equally exact knowledge of the discrete parts of the composite has been attained. Mr. d'Abro defines the "scientific reality" as nothing more than the "simplest co-ordination of scientific facts, hence, ultimately, of sense-impressions." Yet these sense-impressions are necessarily gross and inexact. There is, moreover, a different and more exact method of attaining knowledge.

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[1] A. d'Abro: *The Evolution of Scientific Thought.*

Mr. d'Abro says:

> Structure, as outlined above, resolves itself into those mathematical relationships or equations which appear to account for the sequence of phenomena. But structure in the more usual sense would apply to the hidden mechanisms themselves, to the deep-seated, underlying causes. When, however, we wish to attain this more con-

> crete knowledge of structure, we encounter a number of difficulties. As Poincaré points out, every time conservation of energy and the principle of least action are found to be satisfied (as is the case in electromagnetics, for example), an indefinite number of different mechanical models are possible; so that our knowledge of the structure of the world is vitiated by the fact that the substructure remains indefinite. (p. 402)

Let me ask the scientist just at this point what the result would be if one interpreted phenomena (and predicted results) on the assumption that mental Purpose was the cause of all structure, and of all structural changes? What then? Would not the mind perhaps then be able to understand the nature of structure in its more intimate details? Could not the mind predict the one result (out of the many possible to mechanism) that was *mentally* necessary? Would this, then, not be the inevitable result, the one ''necessary'' in experience? Is pure mechanism the proper principle to rely upon? Is it the best guide? Why follow it if its guidance brings us not to one but to numerous possibilities? Surely we must rely upon another principle if we would attain a finer knowledge. Only Purpose can perhaps distinguish between the numerous possibilities of all those which may equally subscribe to the principles of mechanism. Surely mechanics can never point the way to truth here.

The scientists are hopeful of attaining exact knowledge through use of the mathematical method because they see its moments of triumph. They temporarily forget the far-reaching failures. Mr. d'Abro says: ''Nature seems to be amenable to mathematical investigation and to be governed by rigid mathematical laws, at least to a first approximation.'' (p. 411) Is this true, however? Is the mathematical demonstration *always* true even approximately? Quite the contrary, I should say. Mr. d'Abro continues, however, ''So far as scientists are concerned, this belief is not the outcome of religious or philosophical presuppositions. Rather it is a belief which is forced upon our minds by the triumphs of theoretical physics, the first grand example of which was afforded by Newton's celestial mechanics.'' Yet this celestial mechanics, as is now admitted, contained error—even as a generalization. Mr. d'Abro himself remarks: "The fact is that mathematics consists in compounding the similar with the similar; wide heterogeneities even among quantities would render an appeal to mathematics useless." (p. 412)

Yet, who is thus able to recognize the similarities? And who can even identify the edges of composite groupings, unless the particulars are known? A heterogeneity begins at the edge of a particular, but it also begins at the edge of every composite. And then Mr. d'Abro makes another statement that seems to be rather inconsistent—especially in view of his earlier admissions that energy appears everywhere to be discontinuous, and that even space and time seem to be atomic—namely, that (for mathematics to be practical) there is "another condition which must be found in nature, and that is continuity. Mathematics is capable of attacking problems where discontinuities are present, but the technical difficulties are very great; and this is the chief reason why the theory of numbers presents such obstacles. On the other hand, where we are dealing with problems of continuity the mathematician feels more at ease; and that superb mathematical instrument known as the differential equation becomes applicable." (p. 412) Immediately, however, he makes a confession that has the effect of reducing the value of mathematics. It is this: "Incidentally we can understand why it was that Planck's discovery of quantum phenomena [really leading to the conclusion that the idea of continuity is unreal], or discontinuous jumps in the processes of nature, was such unwelcome news to theoretical physicists; the differential equation had lost its power." (p. 417)

Mathematics did not lose its power because of Planck's discovery. It has always been inexact because it has always been philosophically unsound, and this is so because the very idea of continuity of force is unreal. If the mathematicians had relied more on reason and less on experience they would not have constructed this edifice that they must now tear down.

Mr. d'Abro finally makes this most necessary and gratifyingly frank admission: "And yet, in spite of this mathematisation of physics exemplified in the works of the theoretical physicists, physics is not mathematics, and truth in physics is not the same as truth in mathematics.'' (p. 414)

And what more can the philosopher ask of the scientist than the following admissions?

> There is every reason to believe that even Einstein's mechanics is but an approximation to truth. (p. 414) The fact is that we are by no means certain that nature is amenable to rigorous mathematical laws and that the so-called constants of physics represent other than average values. The triumphs of theoretical physicists suggest that a mathematisation of physics is permissible as a first approximation; but a closer microscopic survey might prove that this appearance of mathematical purity and simplicity in nature was due to our crude macroscopic survey of phenomena. For instance, it is a well-known fact that if conditions are sufficiently chaotic, the chaos will generate simplicity when we view things from a macroscopic standpoint; it is only when we wish to view things microscopically that the chaos appears and mathematical methods become impossible. (p. 414)

As Mr. d'Abro says, mathematics becomes unsatisfactory as one approaches the unit reality—and it will doubtless continue to be thus inapplicable until it is reconstructed on a basis that subscribes more to reason and less to the merely approximate facts of gross sense-impressions. Yet Poincaré is right in asserting that a great deal of value can be attained from the broad mathematical interpretation, that is, from the macroscopic view. In certain situations even the Conservation principle proves useful.

The scientist is inclined to deride the philosopher who relies more upon general reasoning than upon experience. Many assert that only the empirical scientific method can bear fruit. The scientist believes he is never utterly wrong in his philosophic view, for his philosophy is based upon his experience, and he believes that his experience is correct so far as it goes. Is it indeed?

Mr. d'Abro, in attempting to justify the scientific methodology in the face of its inner contradictions, says:

> This dual tendency in science, that of atomism versus the general principles, that of the microscopic versus the macroscopic, must not be thought to arise from any peculiarities in the philosophies of the various scientists. It is due to the circumstances under which they happen to find themselves. Thus, we see a theoretical scientist such as Einstein adopting a phenomenological attitude when investigating the difficulties attendant upon the negative experiments; and we see the same scientist, Einstein, adopting an atomistic attitude when studying the problems of Brownian movements, the problems of radiation, or the quantum theory of specific heats. . . . So it is in science; and we may be quite assured that in the years to come, as in the past, we shall continue to witness these periodic swings from the macroscopic to the microscopic view, from the general principles to atomism. We must realize, however, that as each swing takes place we are advancing higher and higher towards the unattainable ideal, perfect knowledge. (p. 417)

It is remarkable that the scientists are able in any way to justify their use of utterly opposed views as explanations of phenomena in like physical kind. It is also remarkable that they assume that more perfect knowledge is attainable only through minute and painstaking accumulations of statistics when, in fact, these statistics refer only to gross events. Why should they think they will approach knowledge closer and closer through the continuation of a method which up to this time has developed inexplicable paradox in almost every scientific field? It seems to us that the mathematical method of to-day is only partly pragmatic. We deny that it is sufficiently exact ever to be thoroughly practical. We deny, too, that it is the best method of attaining correct knowledge. Finally we deny that mathematics is now all that it might be. It should be corrected now to accord more with reason. Because the mathematical formulation is so faulty, because the number-system is so crude, because the scientific methodology is so imperfect, the scientist has been forced to the conclusion that: ''Obviously, there is nothing in the nature of an explanation in a scientific theory. Phenomena are not explained; they are merely interconnected, or described in terms of their mutual relations. As a matter of fact, there is no cause to be surprised at this failure of science to explain phenomena, for the failure arises not from the limitations of science, but *from the limitations of the human* mind itself. (p. 426)

Here we see the scientist loyally clinging to the idea that his scientific method is perfect even though his mind-power be insufficient to apply it. We wonder how he can be sure that this insufficiency of mental capacity has not also led him to adopt a wrong premise for his science—as well as a faulty methodology. Perhaps he is now in such utter confusion because he is so devoted to his present faulty method, because he is so deep in his rut of statistical experience, because he is sure that pure reason cannot be used helpfully in solving his problems. It would seem that he has not sufficiently made use of his mental capacity. Perhaps the scientist is too much of an empiricist and too little a philosopher. Perhaps, after all, the philosophic method *does* attain the highest truth. As things stand to-day, the scientist is obliged to confess that his most stupendous efforts have reached paradoxical conclusions. He says: "Clearly, those who seek explanations will find no comfort in science. They must turn to metaphysics." (p. 427)

And, as Professor A. S. Eddington says in his beautiful book, *The Nature of the Physical World,* "It now seems clear that we have not yet got hold of any primary law—that all those laws at one time supposed to be preliminary are in reality statistical." (p. 98) In speaking of mathematics he remarks:

> The pure mathematician, at first called in as servant, presently likes to assert himself as master; the connexus of mathematical propositions becomes for him the main subject, and he does not ask permission from Nature when he wishes to vary or generalize the original premises. Thus he can arrive at a geometry unhampered by any restriction from actual space-measures; a potential theory unhampered by any question as to how gravitational and electrical potentials really behave; a hydrodynamics of perfect fluids doing things which it would be contrary to the nature of any material fluid to do. (pp. 161–2)

Then Professor Eddington describes the result of the scientific method:

> For at least fifteen years we have used classical laws and quantum laws alongside one another notwithstanding the irreconcilability of their conceptions. In the model atom the electrons are supposed to traverse their orbits under the classical laws of electrodynamics; but they jump from one orbit to another in a way entirely inconsistent with those laws. The energies of the orbits in hydrogen are calculated by classical law; but one of the purposes of the calculation is to verify the association of energy and period in the unit *h*, which is contrary to classical laws of radiation. The whole procedure is glaringly contradictory but conspicuously successful. (pp. 193–4)
>
> We must, of course, look forward to an ultimate reconstruction of our conceptions of the physical world which will embrace both the classical laws and the quantum laws in harmonious association. (p. 195) We must not try to build up from classical conceptions because the classical laws only become true [do they ever become true?] and the conceptions concerned in them only become defined in the limiting case when the quantum numbers of the system are very large. (p. 197) For low numbered states the current vocabulary of physics is inappropriate; at the moment we can scarcely avoid using it, but the present contradictoriness of our theories arises from this misuse. For such states [and here Professor Eddington reaches exactly my concept] space and time do not exist—at least I can see no reason to believe that they do. But it must be supposed that when high numbered states are considered there will be found in the new scheme approximate counterparts of the space and time of current conception—something ready to merge into space and time when the state numbers are infinite. And simultaneously the interactions described by the transitions of states will merge into classical forces exerted across space and time. So that in the limit the classical description becomes an available alternative. Now in practical experience we have generally had to deal with systems whose ties are comparatively loose and correspond to very high quantum numbers; consequently our first survey of the world has stumbled across the classical laws and our present conceptions of the world consist of those entities which only

> take definite shape for the high quantum numbers. But in the interior of the atom and molecule, in the phenomena of radiation, . . . the state numbers are not high enough to admit this treatment. These phenomena are now forcing us back to the more fundamental conceptions out of which the classical conceptions (sufficient for the other types of phenomena) ought to emerge as one extreme limit. (pp. 197–8)

Professor Eddington says, too, that: "It has become doubtful whether it will ever be possible to construct a physical world solely out of the knowable—the guiding principle in our macroscopic theories. If it is possible, it involves a great upheaval of the present foundations." (p. 228) He asserts that the laws of Nature that have been used in science, "cannot be regarded as genuine laws of control of the basal material of the world. Statistical laws relate to the behaviour of crowds, and depend on the fact that although the behaviour of each individual may be extremely uncertain average results can be predicted with confidence. Much of the apparent uniformity of Nature is a uniformity of averages." (p. 244) How great a principle of truth is involved in his statement that "the greater difficulty in elucidating the transcendental laws is due to the fact that we are no longer engaged in recovering from Nature what we ourselves have put into Nature, but are at last confronted with its own intrinsic system of government." (p. 245)

These pages by Professor Eddington were read after my own work had been prepared for publication. I am incorporating them because they confirm much of my view. As he says: The laws "which we now recognize as man-made are characterised by continuity, whereas the laws to which the mind as yet lays no claim are characterised by atomicity. . . . Perhaps our final conclusion as to the world of physics will resemble Kronecker's view of pure mathematics: 'God made the integers, all else is the work of man'." (p. 246)

In this now admitted failure of the classical theories, in this unsettling of the very foundations of the old physics, and in this proof of the insufficiency of present-day mathematical formulations, one finds a breach in mechanical positivism large enough to suit the most ardent spiritualist. Indeed, before we can explain the motions of matter in our universe we must admit the presence of a spiritual Force as a participating and potent Cause!

Let us go, then, even farther than Dr. Millikan, and discard this inconsistent and depressing theory of a universe operated on a purely mechanical basis. Let us not rely on the Einstein formula—a formula still based on the mechanical Conservation of matter and its energy—as an excuse to retain unadulterated mechanics; but let us rather admit the reality of this dualistic world, and cheerfully welcome into it the influence and mental plan of that active Cause which our very souls desire. Let us reorder our mathematics and our physics by introducing mentally *arranged* and accomplishing motion as a fundamental part of them. Then, perhaps, we can dispel the inconsistencies which remain even after the formulas of Relativity are used.

After discarding the present-day theory of a universe which is operated purely as a mechanical monism, and after rejecting this depressing doctrine of Conservation and futility, how comforted should he be who for his happiness requires faith in an omnipresent Cause! How free, also, the philosopher may feel who accepts the new conclusions! How happy should he be to realize that Reason need no longer humble itself merely because a science of numbers (partly untrue of this world) and a science of physics (now proved inadequate and unreal) give a contradictory verdict! Surely the gates are now about to swing open to admit a superior knowledge—to receive a theory and a formula true even of the particulars of life.

To place our philosophy properly, we must reconstruct our mathematics; and the first step of reconstruction comes in the understanding that the tiny influences known as "infinitesimals" may not be ignored; and that there is no infinity of matter, or of continuity either, in the smallest composite or in the widest universe also composite. Only the smallest bit, the physical unit itself, that which gives reality to all, is to be discovered in the majestic simplicity of unit physical truth, of complete solidity, and of unfailing continuity from limit to limit. This unit, this humble particle, perhaps forever indetectible but nevertheless supreme in the physical world, is no longer to be rejected as worthless, nor is it to be regarded as if it could compose a continuity longer than its very self. Nor is it to be thought that any action with which it might be endowed, or which it could endow, could afford a continuous display of force. Rather, its truths of physical solidity, and characteristic separateness—and, finally and most importantly—of evolutionary changeableness, should be exalted until they constitute all reality, and until all the reality of physics consists of them. Its existence justifies the use of numbers.

When this smallest of solids—the foundation of the reality of physics—is correctly rationalized, it should be possible to associate these minute bases of reality into a composite, or synthesis, which, in its physical parts at least, will represent all the truths of the physical universe from its core to its outer limits. The fact of these restrained volumes standing for a synthesis of order of which the parts partake, of these powerful and ''absolute'' reversals of motions at these definite bounds, can never be explained by an abstract mathematics, or by a purely mechanical physics. Nor can the Evolution of matter and its energy be interpreted materialistically. Nor can the Evolution of species be so explained. All these mechanical mysteries disappear, however, when once the presence of a mental principle of force is admitted as the creator of the motions, the ordered rhythms, the restraints, the Evolutions of matter breaking momentarily into the order of the whole, and of all the sensations and significances of life.

CHAPTER XVIII

BASES FOR RELIGION IN A CORRECTED SCIENCE

> Whatever else be certain, this at least is certain,—that the world of our present natural knowledge *is* enveloped in a larger world of *some* sort of whose residual properties we at present can frame no positive idea.
>
> WILLIAM JAMES.

OSWALD SPENGLER in his difficult book, *The Decline of The West,* views mathematics and physics somewhat as I do. For example he says that there are several strictly mathematical kinds of three-dimensional extension, "none of which can be singled out to rank as the genuine 'form of perception' " (pp. 170–1); and then he voices my own conclusion, though from a different point of view, when he states "that in reality there is only one true 'dimension' of space, which is direction from one's self outwards into the distance, . . . and that the abstract system of three dimensions is a *mechanical* representation (italics mine) and not a factor of life." (p. 172)

He remarks also that "It was a grave, and in a contemporary of Euler and Lagrange an unpardonable, error to postulate that the Classical school-geometry (for it was that which Kant always had in mind) was to be found reproduced in the forms of Nature around us. In moments of attentive observation at very short range, and in cases in which the relations considered are sufficiently small [I should prefer to say sufficiently general] the living impressions and the rules of customary geometry are certainly in approximate agreement. But the *exact* conformity asserted by philosophy can be demonstrated neither by the eye nor by measuring instruments." (p. 171). The form of perception, he says, is "in fundamental contradiction with mathematics." I should go farther, and say that mathematics contradicts reality as well as sense-perceptions.

I am particularly interested in a proper interpretation of the physical realities, and not so much in the question of whether our sense-perceptions are able to obtain a clear or accurate opinion or view of them. Indeed, I hardly see how our perceptions of the physical could be accurate, standing as we do in one spot, and judging as we do from the impressions made on us there—and not everywhere—by incoming rays. That which we observe is sure to be localized in its focus upon us, and then, again, we observe the small thing with gross inaccuracy. Only Reason, with a generalizing imagination, may abandon this localized point of view and get at the truth broadly—and only Reason can attempt to interpret that unit situation which no instrument is able to reveal to direct perception.

Mr. Spengler says:

> The outcome, then, of Gauss's discovery, which *completely* altered the course of modern mathematics, was the statement that there are several equally valid structures of three-dimensional extension. That it should even be asked which of them corresponds to actual perception shows that the problem was not in the least comprehended. Mathematics, whether or not in employs visible images and representations as working conveniences, concerns itself with systems that are entirely emancipated from life, time and distance, with form-worlds of pure numbers whose validity—not *fact-foundation*—is timeless and like everything else that is "known" is known by causal logic and not experienced.[1]

Spengler does not emphasize the point that this abstract mathematics is entirely *too* generalized to be appropriate for use in reference to physical particulars,—or in a philosophy concerning these particulars,—but he indicates that it leads away from perceptive experience, and from the great meanings revealed in intuition. He says: "With this, the difference between the living intuition-way and the mechanical form language became manifest and the secret of *spatial*

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[1] Oswald Spengler: *The Decline of the West,* p. 172.

becoming opened out.'' He also emphasizes too much, I think, the importance of the individualistic or human viewpoint.

To obtain the true understanding, one must ''comprehend'' the ''thing-in-itself'' as it is both in the wide ranges and in its own inner being—and certainly must not judge it from any one focal point, or from the standpoint of an emotional perception unsupported and uncorrected by a general mental judgment. Intuition, instinct, can disclose much, and may be more logical than our present-day logic, but it cannot possibly disclose the All. The final knowing is to be the accomplishment of mind outspread, generalized, with its broad findings averaged and interpreted so as even to define the particular properly. Knowledge of that which lives behind the material veil is not to be derived, as now, almost altogether from that hazy feeling which seeps into the consciousness from subconscious depths.

Mr. Spengler cuts into physics with a sharp knife, and a proper surgical operation it is. ''Western Physics,'' he says, ''is by its inward form dogmatic and not ritualistic. Its contents is the *dogma of Force* as identical with space and distance. . . . Consequently its tendency is persistently to overcome the apparent. . . . ''Force'' is a mythical quantity, which does not arise out of scientific experimentation but, on the contrary, defines the structure thereof *a priori.*'' (p. 412)

Thus, magnetism is a ''field of force which includes a piece of iron.'' Personifications are imaged ''like 'electricity', 'temperature', and 'radio-activity'.'' ''This 'force' or 'energy' is really a numen stiffened into a concept.'' (p. 413) This is ''shown by the often overlooked fact that the basic principle known as the First Law of Thermodynamics says nothing whatever about the nature of energy, and it is properly speaking an incorrect (though psychologically most significant) assumption that the idea of the 'Conservation of Energy' is fixed in it. Experimental measurement can in the nature of things only establish a *number,* which number we have (significantly, again) named *work.* But the dynamical cast of our thought demanded that this should be conceived as a *difference* of energy, although the absolute value of energy is only a figment and can never be rendered by a definite number. There always remains, therefore, an undefined additive constant, as we call it; in other words, we always strive to maintain the image of an energy that our inner eye has formed, although actual scientific practice is not concerned with it.'' (p. 413)

Here Mr. Spengler speaks of the ''additive constant'' as though it were or could be used to make mathematics correspond with sense-perceptions, whereas, as the reader will have observed, this constant is necessary to make the generalized mathematical formula fairly true of a space containing both matter and nothingness—that is, containing both force and intermissions without force-expressions. The mathematician, as he uses his theories, is not concerned with eyesight, with point of view, or with individualistic sensations. The bridge he builds over the chasm, so long as it conforms with his formulas of strains and stresses, and has the proper factors of safety for his materials, will support its load just as well if poison gas should thereafter exterminate the entire human family and eliminate human perception from the scene. The perceptions of mechanical forms do not limit the realities of the forms, nor should they limit the mathematics fit to describe or interpret them.

Mr. Spengler says that the force-theory is a dogma, not an understanding. Heinrich Hertz ''tried to resolve the dilemma of mechanics by *eliminating* the idea of force.'' (p. 414) Yet, '' 'Modern Statics' is in the same position as 'arithmetic' and 'geometry,' which . . . are void of meaning in modern analysis, . . . and only preserved because our reverence for all things Classical has hitherto debarred us from getting rid of them or even recognizing their hollowness.'' (p. 414)

Even temperatures, as he says, is an off-shoot of the motion—or force-principle. Newton conceived mass, too, ''*as functional*—the world as a function to God.'' (p. 415) Mass is to-day defined as something varying with motion. That means that it, too, is a product of motion of force. Yet, the cause of motion is unknown to science. Therefore, the causes of mass and of temperature are equally unknown.

When speaking of the theoretical ''attraction'', Mr. Spengler says: "To this day no one has produced an adequate definition of these forces-at-a-distance. No one has ever yet understood what centrifugal force really is. Is the force of the earth rotating on its axis the cause of this motion or *vice versa?*" (p. 416) And then he asks: "what is the difference between force and motion?" Faraday (a "visionary" Mr. Spengler calls him) observed in 1846: "I assume nothing to be true in any part of space (whether this be empty as is commonly said, or filled with matter) except forces and the lines in which they are exercised." Spengler then remarks that "Here Faraday is metaphysically one with Newton, whose forces-at-a-distance point to a mythic background that the devout physicist declined to examine."

The motion problem, he says, is as insoluble as ever, and "*Nature is doing work;* for every 'process' within the meaning of the First Law of Thermodynamics is or should be measurable by the expenditure of energy to which a quantity of work corresponds in the form of 'bound energy.'" (p. 417)

Mr. Spengler refers here apparently to a phenomenon like that exemplified in the motions of the air-molecules in a balloon, wherein the particles are reversed at the bounds of the balloon without an identified source of the expenditures of energy. This *must* be explained, however (and also the movements of the electron spontaneously towards the nucleus, and many other phenomena inconsistent with mechanics), and if we trace the particles of moving matter delivering this energy, we shall find them continually re-locating themselves farther and farther away, transferring the source of power to a volume of matter in motion just beyond that under consideration, until, at last, we come, through Reason alone, to the opinion that Nature is doing her fundamental causative work at her outermost physical bounds, and that the source of all these internal motions and energies is situated at these circumscribing and restraining borders. Here at the bounds we locate a Power that *does,* and here we discover the Cause of all those inner forms and restrained motions which the mathematician formulates experimentally at the very time he denies the Cause.

Mr. Splengler goes on thus: "This is the origin of the sudden and annihilating doubt that has arisen about things that even yesterday were the unchallenged foundations of physical theory." (p. 418) Statistical methods, as he properly says, are now relied upon to confirm what previously was supposed to be infallible theory. And even "The theory of gravitation, which since Newton has been an impregnable truth, has now been recognized as a temporally limited and shaky hypothesis."

Even the Conservation hypothesis receives its criticism. This doctrine, he says, "has no meaning if energy is supposed to be infinite in an infinite space." (p. 418) This supports my view. Then he remarks reasonably that if we refer to a finite and bounded system of bodies "not externally influenced," such a limitation cannot, in actuality, exist. This signifies, as I have said before, that the molecules in the balloon could not be reversed by the cover unless there were an "absolute" energy-influence external to this cover and still another influence beyond that, to deliver the force used in accomplishing the repeated reversals of motion.

Mr. Spengler observes that the idea of the ether has been broken down from internal contradictions. Lord Kelvin, he says, "has proved mathematically that there *can* be no structure of this light-transmitter that is not open to objections." As to the theory of light. "The Maxwell-Hertz equations of the Electromagnetic Theory of Light, which in fact are pure nameless numbers of indubitable validity, exclude the explanation of the ether by any mechanics whatsoever." (pp. 418–9)

I shall not proceed further with Mr. Spengler's analysis, interesting and pertinent as it is, but will refer the reader to the book itself, and particularly to those pages which discuss the theories of Relativity, Entropy, Radioactivity, and which submit these subjects to a severely critical analysis. Almost every sentence confirms my separate proof of the unreality of much of our supposedly exact science. I differ from Mr. Spengler, not as to his statements of fact, nor as to his criticisms of mathematics and physics, but only as regards the conclusions that he draws.

Let me now end this short chapter by quoting the author with whom it began. William James believed in a religious life, in a life of communion with an unseen spiritual power. This unseen God could not be proved scientifically, perhaps, but He could be dreamed about dimly; could be recognized intuitively; could be presupposed; could be accepted by faith; could not positively be denied by science; and could, if deliberately added to our lives by our own wills, influence greatly our doings, our happiness, and our feelings. This "willed" but as yet undemonstrated God, can neither be denied nor proved absolutely by anyone; but every one may have faith in Him in the same practical way that scientists have "willed" to have faith in the value of their experimental data. Indeed, when a God is accepted as a real Presence by will, or by a welcoming faith, He enters powerfully into life, thus seemingly proving Himself real. He then adds more values to existence than the cold, brittle findings of science have done thus far—or may ever do. Some day, thought James, the presence of this God will be proved more conclusively than science, in this day, has proved the ultimate truth of its laws. At present, said he, "our science is a drop, our ignorance a sea."

This was no exaggeration. What right has science to be dogmatic? The true scientist is not stubborn in his views. As James said, "If your heart does not *want* a world of moral reality, your head will assuredly never make you believe in one."[1] "*And where faith in a fact can help create the fact,* that would be an insane logic which would say that faith running ahead of scientific evidence is the 'lowest kind of immorality' unto which a thinking being can fall. Yet such is the logic by which our scientific absolutists pretend to regulate our lives."[2]

There is much common sense in what James thought. Long before the time had arrived to prove that nineteenth century physics was untrue in fundamentals, the phenomena appearing in religious experiences perhaps gave us a right to assert the reality of a spiritual Power outside of physical nature, of a God with whom the spiritual part of us might commune, and by whose whisperings we might be guided. This knowledge of the religious person comes from a vital part of his being, just as the intellectual judgment of the scientist also comes from some attribute within. Each of these types of mental appreciation is a real quality of life; and certainly one would be bold to give the higher place now to logical reasoning. Man to-day has little reasoning ability. He expresses mostly subconscious mental powers. Only very occasionally, relatively speaking, do subconscious thoughts drift into the realms where conscious logic can grasp and make use of them. One might be justified, then, in asserting that intuition is still the higher quality, and that it serves us better than conscious thoughts as a guide to religious truth.

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[1] William James: *The Will to Believe,* etc., p. 23.

[2] *Ibid.,* p. 25.

These statistics of science, which from the time of Kepler up to 1900, at least, seemed to leave no place for the intervening God of the religious person, have been compiled largely by the conscious powers of man. His mechanical system has been formulated partly by muddling along, and by trial and error methods, but partly also by the aid of an imagination which has permitted him to comprehend and measure the meanings of his experiences, and to correlate similar happenings into principles, or laws, of expected repetitions under similar conditions. Occasionally, too, imagination has pointed ahead to the experiment *to be made* in order to prove something which perhaps now is but a reasonable surmise. Reason, likewise, has entered into science; but this mental attribute has been relatively feeble—so much so that William James, from the very nature of things, questioned the dependability and inclusiveness of the scientific doctrines which were then so dogmatically asserted, even though so grossly developed. He gave religious intuition a higher place than the contradictory implications of these findings. Nor did he find any basis for religion in these materialistic principles as scientifically set forth.

Physical Nature seems to be unconcerned about our happiness. We usually call this Nature "She," but "It" might be the better pronoun, so impersonal is this mechanical world of matter. Her paths, as interpreted by the physicists at least, are systematically methodical, largely repetitive, up and down, following mechanical compulsion solely, and not any moral purpose. There is also much evil in Nature.[1]

William James perceived these things clearly, and could not adore the physical aspect of the world as the final gift of God to man. "Beauty and hideousness", he said, "love and cruelty, life and death keep house together in indissoluble partnership; and there gradually steals over us, instead of the old warm notion of a man-loving Deity, that of an awful power that neither hates nor loves, but rolls all things together meaninglessly into a common doom."[2]

Can one worship such an automaton? God, the Deity whom one might trust and love, thought James, must be a Cause superior to this mechanical routine of matter—to this automatic chain of cause and effect which distributes its joys and woes so unfeelingly and indiscriminately. He therefore denied the validity of the Nature-God of Spinoza—not so much the validity of the laws of nature as set forth scientifically, as the idea that God could be discovered in materialistic realms, or that the realm of matter was the All. Reflections about such a hopelessly unfeeling Divinity, a God unemotional and unsympathetic by His very nature, inevitably induce melancholy. "Pessimism is essentially a religious disease." It is the outgrowth of the wrong sort of religious opinion—or of the lack of religious conviction—which comes often from ascribing Godhead to a mechanically systematic Nature, a Nature, which, as the scientific mind has charted it, can contain no real spirituality, no basis of hopefulness. Being purely mechanical, it can express no morality, no gladness.

When one thus views Nature, and its doings—and then, because his thoughts are too feeble to rescue themselves, accepts the present scientific principles as everything—what possibility has he of being either religious or melioristic? If mechanism as taught to-day is unquestionably true; if the various orderly motion-series of the "sensed" physical world are regarded as the sole realities; if the only acts of God which reach man are the blows of the solid particles which are supposed to move in an unaccomplishing and perfectly balanced mechanical routine, then the prospect of man would be indeed hopeless. It would seem wiser, indeed, for him to deny his logical conclusions and cling to that which his intuitive faith calls for, even though his reason seems to prove it unreal. Either he must do this or else, basing his belief on that which his weak reason now seems to prove to him—but which is "proved" so erroneously—he will become morbidly unhappy. And when his reason does prove to him that his science is philosophically unsound, then must he indeed strive to correct his science. As a character in Thomas Mann's book, *The Magic Mountain,* so well says, "a cultural conception which refuses to recognize that what is philosophically false cannot be scientifically true, is not worthy the name."

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[1] See Matthew Arnold's sonnet, *In Harmony With Nature.*

[2] William James: *The Will to Believe, etc.* pp. 41–2.

Yet even the most ardent scientist has refused to believe in the denial of the emotional religion which his studies have seemed to demonstrate. The religious feeling, the belief in something which, though outside of mechanics, is nevertheless potent in the universe, and which even makes mechanics and our partly mechanical lives possible, is so universally ingrained—particularly in our powerful subconscious selves—that our most scientific persons, our greatest thinkers, have perhaps been our most truly religious men. They have held these firm religious convictions even at times when they could not be explained in terms which their scientific beliefs would approve.

This book attempts to demonstrate that the laws of the motions, forms, and energies of the physical Nature which we chart, are given to us by a Spiritual Force which to-day acts repeatedly, and which thus affords us all the mechanical forces, motions, structures, and means of sensation of the pressure-pool of the universe. Immersed in and confined to this pool, we investigate, chart, imagine, and reason, all somewhat crudely, and at the present moment we have reached incorrect conclusions concerning the fundamental reality of our environment. The God we should worship is not to be discovered in the approximate consistency of some of the laws of this artificially and spiritually restricted pool of matter, which, within, mostly displays actions equalling reactions. It is natural that we should detect and chart this seeming balance, and even be deceived into thinking it really self-created and self-contained, and *perfectly* compensated. The true God, however, is rather the Power which makes matter do its bidding, which accomplishes something with it, which changes the material relationships from moment to moment, which supplies the moving force-principle to physical substance, and which even produces the orderly relations of the mechanical energy-pool by the constant and absolute expression of Power. It creates also our species, our thought, and our emotions from this otherwise, hard, silent, motionless, cold materialism. Nor is the interior of this pool in perfect mechanical balance. No such negation of evolutionary progress and of mental purpose is to be discovered.

Not a materialistic God, but one of spiritual power, one who can be and is the acceptable maker of our lives, let us worship, and let us make Science include his power even in the realms of physics. His influence both makes and penetrates the world of matter and of sensation. There is a conquering principle of mental force which operates upon the dualism of a world, and which gives reality to both parts of it. To prove this is our task.

William James felt this truth and expressed it: "That the world of physics is probably not absolute, all the converging multitude of arguments that make in favor of idealism tend to prove; and that our whole physical life may lie soaking in a spiritual atmosphere, a dimension of being that we at present have no organ for apprehending, is vividly suggested to us. . . ."[1]

I believe that our physical universe now lies immersed and pulsating in just such a "spiritual atmosphere." It is not knowledge of material nature that we need so much as knowledge of God, of the spiritual which broods over the world, and, in general, has its will with substance. The charting and studying of the material facts, and the interpreting of them correctly, are important philosophically chiefly because they broaden our understanding of the nature and plan of that mental force which makes substance thus move, and thus exhibit to us its phenomena. The more completely we possess this knowledge of nature, the more perfectly can we attune ourselves to the Divine. Professor Eddington says, and he is one of the very few physicists that make even this admission, that, ''religion first became possible for a reasonable scientific man about 1927.''

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[1] *Ibid.*, p. 57.

In the next chapters, then, we should scrutinize closely some of the supposed facts of physics in an attempt to ''broaden'' our understanding of the nature and plan of the mental force, and thus establish more firmly our bases for religion in a corrected science.

CHAPTER XIX

OBJECTIONS TO THE RELATIVITY HYPOTHESIS

> Consider, also, my good youth, that your mind, existing within your body, directs your body as it pleases; and it becomes you therefore to believe that the intelligence pervading all things directs all things as may be agreeable to it.
>
> SOCRATES.

WE have concluded that physical Extension and Time do not take part in the transfers of mechanical energy. Neither participates in the building-up of accelerations; neither is connected in any way with the force-manifestations of the physical universe; both have their reality solely in the physical. The space-volume which lies outside the matter-particles represents material and mechanical nothingness, therefore the theory of ''attractions at a distance'' (by which forces are supposed to be altered solely by changes in the relations of the empty space exterior to the matter-particle) and the theory of Relativity (by which forces are supposed to be altered by the changes in the Time of a moving object) are quite incomprehensible. Time and physical Space, as we now understand them, cannot possibly possess this uncanny ability of changing force by their ''spontaneous'' self-changes.

Professor Max Born expresses the ordinary man's view of the Relativity theory when he writes in *Einstein's Theory of Relativity* that the person of commonplace mind considers it ''sheer nonsense to imagine space being curved.'' Einstein asserts that light exhibits curves partly because the empty space-time through which it passes is curved—curved as to the light by the relative motion of the light.

A body moving between worlds may be curved by some force-action expressing itself in some part of the region, but can we suppose that emptiness alone is potent enough to express the mechanical energy required to deflect light? What is derived from nothingness that compels light to reflect from its sides? Has emptiness some mechanical power? And may it act without an equivalent reaction? May such a nonentity act—even for a moment—contrarily to mechanical Conservation? May energy be created by and out of a void? Have we had any experience in any other realm to make us accept such a theory? Or is it, that, to obtain some sort of explanation, we are willing to ascribe the ability to exhibit independent power to almost anything, even to nothingness, only not to man, nor to his Creator? Is this our reasonableness?

May empty but curved space-time (curved by the presence of mass at a distance), yet *not* a universal Cause, possess both the ability and the will to concentrate the universe? What principle, then, curves the electrons into their orbits within atomic spheres? Isn't this an equal mechanical mystery?

How can something without volition act perpetually in one direction? Why is it that empty space-time curves moving energy forever towards mass at a distance? How can we explain this tendency of mechanical nothingness to restrain the moving parts of the material universe? Why and what is it that thus keeps matter concentrated within definite limits forever, and that forever keeps it in motion? Is it really an all-pervading nothingness that acts here and there; or is it a universal mental Cause controlling the universal Whole?

Shall we stop short, then, when our explanation reaches empty space-time as the principle which causes part of the mechanical curvature, and say that reason requires nothing more? Or, is it not more rational to believe that something non-material, even reasonable, dwells outside the extension of the matter-particles, and that it has its Will with matter? Space may be physically empty although not spiritually so! Shall Reason not believe in the being and power of itself?

Indeed, it seems that the Cause of all motion exists outside of matter intangibly and imponderably. It is unphysical, yet it is something more real than emptiness, more active and purposeful than inertia. The Power that drives the universe may well exist outside of matter. Matter may well be concentrated, not through curves in a space-time which, though empty of matter, is yet rigid enough to deflect moving matter, but it may be restrained by a creative Power, unperceived and existing in non-material space. This Power may not only move matter, but in general restrain and curve it with perhaps the precise average amount of deflection that the physicists have recently discovered in light-rays. Not mechanical Relativity is perhaps the cause, then, but a Power that overrules mechanics,—a power similar in definition and principle to that which we find faintly in ourselves.

Professor Born continues: "If it be admitted that our sense fail in these things, that the methods of physics reach further, we must make up our minds to allow the same to the doctrine of space and time . . . intuition must give way to the judgment pronounced by knowledge."

Is this knowledge as set forth in modern physics so infallible, then, that common-sense, even when supported by intuition, must retire before it? Isn't it possible rather that the premise is false? Are we obliged to accept such inconceivabilities as "curved space" and variable duration merely because experience with light-rays passing between worlds has disclosed curves greater than we had anticipated from the mechanical formulas built upon the strict doctrine of Conservation and premised upon the idea that the motions between worlds—except for gravitational influences—are naturally straight, as Newton said? Have we not in a sense abandoned Conservation when we accept a theory like Relativity, which ascribes to empty space-motion the ability to alter energy—to destroy it completely and permanently, and without equivalent later appearance elsewhere? And what have we received in return for thus sacrificing our reasonableness, and for thus attributing a principle of independent power to emptiness combined with relative motion near mass? Have we now achieved a full explanation—one that satisfies us even as a working rule? Are we reconciled to it from the point of view of mechanical utility? Does the new formula apply everywhere? Does it explain the universe of experience, as it is—between worlds, and also within the atom?

Does Relativity everywhere satisfy the requirements of mechanics? And does it fail only when presented to Reason for her approval?

No, Relativity does not explain everything—far from it! The principle formula of Relativity seems to apply only to certain universal experiences. It is probably as defective in principle as the formula for kinetic energy which it modifies. The attempt is made in Relativity to explain the general happenings between worlds by introducing the greatest of mysteries—*i.e.,* by attributing unreal powers and volitions to abstractions,—but, even then, the theory fails to explain what happens within the atom and the influences at the limited bounds of the universe. It fails to fit in with the particularized or unit event. Relativity appears to be nothing but an unexplained formula that works in some relationships.

If we intend to deny the perfection of the old Conservation principle—as we virtually do in accepting Relativity—and if we are willing to ascribe mechanical power to empty space, why should we follow the old mechanics anywhere? Since matter does not appear to move itself, why not admit that its movements along bending paths with no other source of curvature than Space constitute a phenomenon breaching the doctrine of mechanical Conservation?

The first movements of matter certainly had their beginnings in a principle transcending mechanics. And it is quite impossible to explain the continuance of the *changing* world in terms of a mechanical monism. Why, then, accept unreal doctrines, such as Relativity, in attempts thus to explain the world? Why not admit the reality of the mental power both of ourselves and of an unseen Cause? If mechanical Conservation must be abandoned, why not abandon it completely, and accept mind-power for what it seems to be? Attribute to a mental principle the power, through direct or indirect mediation, to curve the bodies moving in space! Give some credit to the power behind Reason, and then, with the weight of immobile matter partly lifted from us, we may straighten our shoulders and cast our eyes forward and upward—not forever towards the ground. Indeed, we may then perceive our environment anew. We may see our life-situation in its larger aspects as changing, meaningful, and inspired. Best of all we may find it somewhat understandable.

Who has the right to assert that the fundamental truth supporting life must always be mystifying and unreal to reason? Why should general reasoning not inform us when we have reached our truths? How can our reason fail to be satisfied with the truths if the facts of this physical life are themselves created by a reasoning mental power? And if reason were not an attribute of the creative Cause, how could our reason understand anything?

Froude once said he could believe only in a God who did something. Carlyle replied "with a cry of pain which I [Froude] shall never forget, 'He does nothing.'" Now, the God whom we are trying to reveal, does something.

Mechanical Conservation is unreal to reason; and Relativity which calls for curves where the old Conservation called for straight lines, is equally unreal as an explanation. Nor can continuity of matter, force, or curve, be reasonable in this world wherein matter is separated in discontinuous units. Let us dismiss these ideas, then, and let us add to the mechanical formulas, not only the fact of Evolution, but the influence of the Power which causes Evolution. Should not Evolution be accompanied by restrained and finite motions, which, in general, are deflected? Is not this the way one might expect the Creative Power to act as it overrides Conservation here, there, everywhere,—and always? Shall we not always find the light-rays deflected according to a reasoned plan of concentration when thus influenced?

Suppose that light-rays are regarded, not as wave-motions of a nothingness like ether, and not as the effect of projectiles, as Newton believed, but as an unusual wave-series of unusual energies of motion as being transmitted by a material fluid the parts of which are normally oscillating. And suppose we conceive of light as moving, not in empty space, but in a whirling pool of matter, and curving because this whirling fluid medium is being restricted by a mental power into a spherical whole. Starlight, we must then admit, cannot proceed far in straight lines. Indeed, this explanation of curvature seems readily and reasonably at hand. Let us reject space-time as a source of energy. Let us believe rather that a mental principle gives deflection to motions in general as it restrains the moving particles to certain spherical bounds. When this is done we shall learn, perhaps, that none of the events of our universe demand the inconceivable explanations that have recently been offered us, tentatively, by Professor Einstein. Where, then, are we?

Certainly, we have developed ideas of physical Extension and of Time which are neither mysterious nor incomprehensible. We have also given understandable definitions of matter and of its energy. Mind-power has also been defined, and we have accepted it as the primary Cause of the movements of matter. Then, after regarding Purpose as the quality typical of the acts of the mental Cause, we have obtained the concept that the Evolution of matter represents the planned accomplishment of mentally ordained motion.

Let us then renounce the Relativity theory, with its indirect denial of "absolute" Change, and see if we cannot account otherwise for that measure of curvature which does exist, and which, to be in accord with our theory, should be represented in the mechanical formulas. Unless we make this accounting we must accept many incomprehensible paradoxes—like those Spencer, Kant, and Einstein have propounded—and, with even more cause for pessimism, we must surrender the idea that the proceedings of the universe are mentally significant.

The universe *appears* to be dualistic, and to seethe with "absolute" change, but "according to Conservation" neither appearance can be real. If the physicists are right, we must deny all that appears real, understandable, or worth understanding. We must abandon the satisfying idea of progress, and must try to be content with forever undulating meaninglessly on exactly compensating waves of inherited mechanical forces—upon rhythmic motions mysteriously formed and mysteriously perpetuated in a universe of contacts and restrictions which displays no "absolute" change, sense, nor purpose, whatsoever.

Professor John Dewey points out the error in the concept of an entirely stabilized universe. He suggests that some thinkers, accepting the beliefs of Aristotle and his followers, chose this materialistic path of unreality in their first premise, and, for this reason, have reached unreal conclusions to which they still cling. "Science," says Professor Dewey, "seizes upon whatever is so uniform as to make the changes of nature rhythmic and hence predictable. . . . Without the uniformities, science would be impossible. But if they alone existed, thought and knowledge would be impossible and meaningless."[1]

Science has in the past been inclined to accept as final the conclusions derived from the average effect of certain composite experiences. In doing this it has mistaken the unit-principle. The unit-principle which composes and gives reality to the gross event, and to its number-system-formulations, is almost excluded from the usual formula—so much so that the reality cannot be interpreted properly by these formulas. To use the illustration of the Introduction, there may be millions of piles of apples running from one to ten in a pile of which not a single heap (the unit-principle of measure) contains the broad generality that is used in the formula—namely, that there are 5½ apples in the average pile. Yet if we treat in our experiments only with trillions of piles of apples at a time, we shall be perfectly satisfied with the implied untruth of our formula—namely, that the unit pile *does* contain 5½ apples. We shall even then be apt to accept the philosophically inconceivable fact that there might be a fraction of the true unit of matter.

Science has disregarded the cause which makes an event first appear, and then reappear slightly changed. It has failed to consider adequately the mental half of the dualism. Science does not attribute sufficient reality to the presence and characteristic activity of that power which first moves inert matter and then forces a universal symmetry upon the structures of moving parts with which physics treats. Science comes upon the scene after a creative Will has grouped matter into fairly balanced and symmetrical structures, and groups of structures, and then observes and analyzes chiefly the rhythmic movements of these structures as wholes as they oscillate in a pool of pressures.

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[1] John Dewey: *Experience and Nature,* p. 160.

The motions and reversals of motions, and the principles relating to them, may be almost constant and stable, to be sure, but this is so only because the matter of the universe is subjected to a mental influence which is fairly constant in its gift of motion to matter. Thus, the general movements of matter in the physical energy-pool may be as consistent and regular and predictable as the motions of the average couple dancing in a crowded room; and our minds (which occupy bodies that receive the impulses and sensations because they are immersed in a somewhat similar environment) may recognize this general uniformity of motion and pressure, yet may quite fail to realize the power which from moment to moment compresses the matter into its average condition of the pool-formation, which restrains the motions of its parts within the finite volumes such as they are, which makes the couples come into the dance hall and dance fairly uniformly separated, and which thus bestows upon the material parts all of their motions, cohesions, contacts, symmetrical structures, and even changes.

When invisible rays of heat evaporate water-particles very slowly, one by one, we are not conscious of this silent, invisible, and even instantaneous process of change. Only Reason helps us to understand here, for the process is invisible, and is unknown to the physical experience. With the aid of Reason, however, we may be able to realize that the power which causes evaporation might well be that which gives the water-mass its group-formation, its symmetrical (and orderly) dependability, and its subservience to a certain mechanical routine. And then we might extend the influence of this reasonable power, in our imagination at least, until it should become the Cause of all the motions and routine of the universe.

The dissolution of matter is not rapid. From day to day the relationship between matter and mind,—as well as the proportion of one to the other,—varies, but only in the faintest degree. Matter, mentally driven, urged into activity by the supreme Cause of motion, will perform to-morrow almost exactly as it has done to-day, for between the days the quantity of matter and the power of the Cause has scarcely changed its balance. The Cause may be omniscient in the sense that all the life we experience may be subject to its power, but it is neither omnipotent nor infinite.

Now, each day a growing child can throw a ball a bit farther. Each day, too, the ball may become lighter, so that, as the child waxes in strength there will be an appreciable change in the path of the ball. Surely the path of to-morrow cannot be correctly gauged by one who bases the future movements exactly on present experiences! To be accurate in the future the formulations of the past must be corrected to account for the measure of Involution in mass that has occurred in the interval.

According to the physicists who have otherwise viewed the universe, the path of matter *averages* forever the same. Motion, they say, is altogether inherited; and the present mean tangential velocity of all the planets in their orbits is never increased, diminished, nor influenced,—unless perhaps by the increase of entropy, and except as the changes are elsewhere mechanically compensated. The power of ''attraction'', the classic physicists say, prevents endless dissipation; and the power of ''attraction'' is somehow balanced exactly within the whole, so that infinite concentration does not take place. By virtue of no identified principle, the position of average matter is definitely determined, and of itself the earth-sun-relationship has no tendency to concentrate or expand. This is the old mechanical Conservation—a doctrine based on observations during relatively long periods of time of bodies so huge that no change is noted in the invisible and myriad parts. Thus, ideas of ''attractions'' are used to rescue Conservation from its most evident breach. Except for this concept, the curving path of the earth about the sun could not be explained—and cannot thus be explained except when much is ignored and when the principles of mechanics are grossly viewed. Nor can the orbit of the electron in the atom be thus explained.

Changelessness in the direction and amount of force and matter in the universe is the gospel of most physicists. This principle was founded, however, on inexact observations and when ignorance was greater than now and experience more crude. Now it is in conflict with many significant events. Why, then, is it not surrendered? Instead, the physicists inclined to view solely the material and mechanical parts of the universe, and they shut their mind's eye to a greater vision. They refuse also to consider the possibility that there may be a fundamental Change, a very destruction of matter, something which they cannot observe through a microscopic lens. And they now stand facing all sorts of paradoxes because they refuse to deny their favorite axiom and to introduce a strictly mental or spiritual principle into mechanics.

Why do they not see, for example, that matter moves unceasingly from one energy-destroying collision to another? And why do they not perceive that it does so only because an outside mental power with purpose first restrains it, then makes it thus move and contact—and then starts it moving again? Not only do they lack these perceptions, but they fail to see in these contacts evolutionary transformations so effective that the successive movements are never identical!

When the quantity of the physical whole of matter is plotted, the graph is surely not a motionless point. It is not even a perfectly balanced circle, nor an exactly repeating ellipse. It rather resembles a spiral. The mechanical formulas which indicate otherwise are wrong in fact and mistaken in principle. When both mass and motion are considered, the approximately elliptical path of the earth about the sun is not a true oval, nor is it the same, for any two successive journeys, nor is the change completely compensated in terms of mechanics. In fact, the so-called "spontaneous" radioactivity of which we now are aware, would prevent that from being possible. Nor is the motion in the orbit due to an energy inherited from original creation. This last point, particularly, is still to be proved.

The typical physicist believes in a mechanical universe in which matter and its inherent or inherited motion are the primal and unchangeable truths; whereas we are postulating a Change which, although it takes place here and there, involves the all. And the principle of energy-equilibrium spreads the mechanical effect of the Change throughout the universe as rapidly as the particles move—just as is true of every pool of pressure. This Change adds a material relativity to every supposed mechanical exactness. Indeed, no fact is unchangeable in so far as it pertains to the universe of matter. We shall consider some of the mechanical relationships in the next chapters, and those who follow the arguments will perhaps be willing to agree with the statement of the next paragraph.

It seems evident that a measure of mechanical relativity which is the product of Evolution, and the principle that force and substance are discontinuous, must be introduced into the mathematical formulas if they are to become altogether useful, more accurate, and philosophically justified? The mathematical formulations will be accurate only when they have been altered to include both the Evolution of matter, the empty gaps between matter-bodies, and the intervals between their blows. As John Stuart Mill says in his *Logic,* "the character of necessity ascribed to the truths of mathematics" is "an illusion." The hypotheses of geometry are not "absolute truths", but "generalizations from observations, or induction from the evidences of our senses." Therefore, they are not *necessarily* true. And as Sir Leslie Stephen remarks, if this be so, and "if the assumptions are inaccurate or uncertain, the whole superstructure of science must also be uncertain."[1]

Only that knowledge, or formula, then, is exact which incorporates in proper measure, first, the fact of the discontinuity of matter and its energy; secondly, the finiteness of the universe, and thirdly, the influence of the Power that moves and retains the matter within it; and lastly, the influence of Evolution.

Before Evolution may be conceived properly, its cause must be realized and understood. Both the nature and conditions of the unceasing motions and contacts of matter-bodies must be comprehended as definitely as the results of these contacts. Only then shall we be qualified to draw a conclusion.

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[1] Leslie Stephen: *The English Utilitarians,* Vol. III, p. 100.

It has been supposed that the total motion of matter cannot be reduced by collisions, yet we shall find that in some contacts the motions of matter *are* destroyed. Then, after we have admitted that ''absolute'' motions may be destroyed, we must explain the renewals of the motions. And just here we reach an issue which is vital, and which, therefore, must be carefully explored.

If we should be able to prove that there are no ''attractions at a distance'' holding structures together, and if we agree that the structures of all bodies *are* restrained like that of the gas-balloon, not by interior ''pulls'', but by external ''pushes'', we must then admit the reality of an all-powerful exterior Cause which renews from moment to moment those motions which have been cancelled by the collisions of matter-bodies. We must postulate such a power even to explain thermal motions of the molecules of gases, and we must suppose, too, that the motions of molecules which are reversed at the cover of a balloon by blows from the outside, will themselves renew the movements of those interior molecules which have collided head-on and have been stopped. We shall thus obtain two explanations—first, of the reversed motions of particles in every gas and solid; and secondly, of the fact that the corpuscles continue to move even though they surrender all of their motions without compensations when they collide head-on.

Professor Dewey speaks of the instability of our supposedly certain knowledge in a way that supports this argument:

> What is already known . . . is held subject to use, and is at the mercy of discoveries which make it possible. Truths . . . are true *if*: if certain other things eventually present themselves; and when these latter things occur they in turn suggest further possibilities; the operation of doubt-inquiry-findings returns. . . . Although science is concerned in practice with the contingent and its method is that of making hypotheses which are then tried out in actual experimental change of physical conditions, its traditional formulation persists in

> terms of necessary and fixed objects. Hence all kind of incoherences occur. The more stubbornly traditional formulation is clung to, the more serious become these inconsistencies . . . True knowledge begins with opinions . . . When employed as hypotheses they induce experimentation. They then become forerunners of truth, and mind is released from captivity to antecedent beliefs.[1]

Nietzsche says also: "Convictions are more dangerous enemies to truth than lies." And again: "Belief in Truth begins with the doubt of all hitherto accepted truths."

That the utterly materialistic beliefs of many scientists are not true, reason, experience, and the logic of thinkers like Professor Dewey prove. It remains, however, to demonstrate that the transformation induced by the unceasing activity of a power external to matter, *does* add the measure of relativity to mechanics which *is* found there. Not only this, but the new theory must be consistent throughout. It must explain events which are inconceivable as now explained. If this may be done we may abandon the mechanists with their paradoxes and mysteries. They are in such a quaking bog that they must recover the ground of a premise sounder and firmer than that of mechanical Conservation before they can rise to soar. And they need also the spiritual wings of imagination, properly spread and curved and feathered, if they are to pass over the morass of materialism.

Physics must be interpreted, then, in the light of an absolute Power of reversed motions, and in terms of Discontinuity, Finiteness, and Evolution. Let us undertake this gradually, but first let us examine some of the basic physical formulas, for it seems likely that they will be found to contain rather glaring inconsistencies.

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[1] *Ibid.*, pp. 154–5.

CHAPTER XX

DEFINING THE REALITY OF MOMENTUM AS A FORM OF ENERGY

> Impressions come to us four ways: either things are and seem to us so; or are they not and seem not to be; or they are and seem not; or they are not and yet seem to be. Now it is the business of the true philosopher to deal rightly with these.
>
> EPICTETUS.

KENT's book for engineers gives us the principles supposed to relate to a moving body that strikes an equal motionless one head-on: namely, when ''two inelastic bodies collide, they will move on together as one mass with a common velocity.'' All the momentum of the single mass moving at double speed before the contact is to be accounted for after the collision in the slower motion but equal momenta of the two masses. If, moreover, ''two inelastic bodies of equal momenta impinge directly upon one another from opposite directions they will be brought to rest." All of the energy of motion, because all is lost when the two bodies stop moving, ''is used in doing internal work on the bodies themselves, changing their shape and heating them.'' When bodies are stopped by collision, unless some other energy-manifestation accounts for the lost kinetic energy of the parent-masses, motion and its energy would be destroyed without compensation, and the Conservation doctrine would be proved incorrect.

No one has ever seen objects start moving of their own free-will. We have asserted, moreover, that by itself a material body cannot alter its motion. We have said that the energy of moving matter is so primarily real that it can neither be created nor destroyed. If energy leaves one matter-body we think it *must* appear in another—and if on collision it leaves two matter-bodies simultaneously, it must appear immediately somewhere else even though these matter-bodies are separated by empty space from every other piece of matter. This is the classical view. If, however, it should now be discovered that motion *is* destroyed in an absolute sense when solids collide head-on, two questions will immediately arise: What becomes of the motion and its energy? And what is the source of the new energies?

Suppose the earth were brought to rest by collision with another equal planet, would it cease to move? ''The earth would cease to move about the sun'', the mechanist would say, ''but its kinetic energy of motion, as cancelled by the collision, would nevertheless be accounted for completely by the shifts of parts and by its radiations of heat and light.'' ''But would not the battered hulk of the earth immediately start falling toward the sun, pulled there by gravity?'' ''Yes'', the answer would be, ''but attraction is here the maker of the energy and we need not consider it.'' According to mechanics the destroyed motion must all be accounted for by radiations and shifts, but, even after this accounting, a new motion and an energy in a new direction would be given the battered earth by gravitation. New energy of motion, new kinetic energy, may thus be added to the universe by nothing but the force of attraction! Such is one phase of the classic theory. Nor could this gravitational effect as here described be due to curved space-time.

Let us investigate what happens in a collision, then, for perhaps we may thus free ourselves from the unreasonable ideas of ''attractions''—especially as sources of added or extra motions. Perhaps also we may escape a too docile acceptance of the Conservation doctrine. As the first step let us examine the collision of theoretical solids.

Kent states that part of the energy of motion which seems to be lost in a head-on collision of solids is to be accounted for ''in internal work on the bodies themselves.'' Strangely enough, the physicists leave no place for energy-changes that might occur in the imagined ''attractive'' or ''repulsive'' forces of the solids when they come closer together. Apparently these mysterious forces are not supposed to affect the routine of the collision importantly. In so far as Conservation relates to the kinetic energies of motion, it apparently takes no account of the variations in the supposed forces of attraction or repulsion acting at a distance. Only the kinetic energies of the body as wholes are to be accounted for strictly in mechanical terms—that is, by shifts of parts and by energy-radiations. The physical formulas, strangely enough, are regarded here as perfect even though they relate only to the energy of collision. Yet, theoretically, "attraction" should express infinite force when an electron and proton are in direct contact.

Now no one has yet been able to describe the work that might be done in the interior of an entirely inelastic body. Surely, not the unit-corpuscle itself, but only groupings of corpuscles, may be re-arranged structurally. Only multiple or composite bodies with the elasticity that may accompany internal open spaces may suffer "shifts of parts." And, too, as we have already observed, heat-radiations cannot possibly emanate from perfectly solid and inelastic bodies. Many of the more modern physicists admit also that when molecules collide they do not give off heat-radiations as expected under the classic theory. We have discussed, too, at some length the ether-wave and the electromagnetic theories of radiations, each of which is unreal. Neither type of undulation can begin in a perfectly solid and rigid mass. When a body gives out energy-waves either it must be vibrating as a whole, or else its parts must oscillate energetically within the volume of the parent-body. In the first case the parent-body itself must bend and vibrate like the microphone-disc of the telephone. Yet it is impossible that a structure should thus bend and vibrate unless some of its separate parts shift their relative positions. And, too, absolutely solid bodies like the unit-particles of our definition *cannot* display internal oscillations. A heat-emitting body, that is, a body with thermal motions—whether emitted heat represents the emanation of tiny matter-bodies or of waves of energy—must be a body composed of many separate parts with empty spaces between them.

One finding of physics confirms this view: The colder a gas is the more solid it is: Its volume reduces in proportion to its fall in temperature. The open spaces lessen uniformly with the decrease in temperature until at absolute zero (minus 273 degrees centigrade) the volume of the gas is supposed to become almost nothing. This means that when thermal motions are absent from a gas its material parts will be in solid unyielding and inelastic formation. Physicists admit that any material structure (whether derived from a gas or otherwise) which is perfectly solid is also perfectly cold. When the parts of a composite display thermal oscillations,—that is, when the body possesses temperature,—it may no longer be regarded as a solid. Heat and solidity are incompatible properties. They cannot appear together in the same object.

We conclude, then, that only the expanded composite body has heat potentialities, and that it must always be somewhat hot, for its parts must always be moving. All composite bodies *must* be expanded, for in the pool of the universe it is impossible that two of the smallest bits of matter should remain together in persisting contact. There are no infinite, or even finite, ''attractions'' between any two of them. It is likewise impossible that two air-molecules should remain quiet inside a balloon while surrounded by other particles all energetically moving. Attractions and repulsions, as we have said, do not create the movements of molecules within the balloon, but external blows do, and these thermal motions, as they are called, soon reach every particle of matter within the volume. This principle is true of every structural formation.

When a composite body is expanded, elastic, and hot, some of its parts may then be emitted; for not only are they separate, but they vibrate like pendulums. Shifts and radiations of the parts of such a composite may be expected after every collision. The solid unit of matter, however, must radiate as a whole. Hence it can never remain in one spot and give off heat to objects outside of this spot. Indeed, none of its internal qualities can ever be known through physical experience, for if they could be known the unit-particle would have lost something *of* itself—would no longer be what it was. Qualities that may be known in a volume exterior to that which is displaying the qualities, like temperatures and colors, are derived solely from expanded and elastic composite. Having reached this conclusion let us use it in our argument.

When the one smallest bit of matter collides with another, it has limited possibilities. It may move as a whole; it may be brought to rest; or it may disrupt. Other things it cannot do: It cannot be hot, and its parts cannot shift. Since the smallest bit, however, is the unit of energy, of resistance, of proper numeration, and of mass, and since it is the only true solid, it is the *only* body to which the theory or numerical formulations of the collisions of inelastic solids might perfectly apply. Yet, in reference to it the statement that heat-radiations or shifts of parts might occur sufficiently to account for the lost energy of relative motion when two particles collide head-on and come to rest, is clearly out of the question. The theory that heat-radiations inevitably result from collisions is evidently a rough generalization, and is untrue as a unit-principle.

If this argument is sound, every time two unit-bits collide head-on the principle of Conservation is breached, for the energy of the particles is destroyed without being otherwise accounted for. We have so much confidence in our definition of the unit of matter, and in the conclusion we have reached, that we believe energy *is* destroyed in every case of solid collision. We believe, too, that the theory of physics which indicates otherwise must be merely one more of those special cases treating in general terms with the composite bodies of our usual experience. In the conventional theory, the source of the power of the thermal activities has not been identified. If we do not know what power finally reverses the tiny particles as they move back and forth in every structure, what right have we to say that they do not stop entirely when they collide midway, and lose energy entirely, without compensations? Why should they not stop and then be started by the passed-on force which acts at the bounds? Who is wise enough to deny that energy is being constantly cancelled and then renewed? Why do the physicists themselves now admit that there may be a breach in Conservation in the inter-atomic phenomena?

Let us designate as "A" the first case mentioned by Kent in which two equal and inelastic bodies collide when only one is moving, and when both are supported (in vacuo) by a flat and frictionless surface. It may readily be proved by the formulas that one-half the kinetic energy of the moving body is lost in this collision. That is to say, after the contact, the kinetic energy of the two bodies (when moving together) equals one-half the energy of the single one moving before contact. This amount of kinetic energy must be accounted for, the nineteenth-century physicists said, in heat-radiations and in shifts of parts. Let us assume for the moment that this kinetic energy may be so accounted for. Let us imagine that this inconceivable is conceivable, and then let us proceed with the argument in order to show that still other inconceivabilities crop up.

The formula for kinetic energy reads: "Kinetic energy (e) equals one-half of the product of the mass (m) by the velocity squared (v^2)." It can be written: e equals $\frac{1}{2}mv^2$. No explanation is given as to what we mean by the multiplication of a mass by a velocity.

Let us suppose that an inelastic mass, M, moving at a velocity of 2V, strikes another equal and solid mass, M, which is at rest. After the collision, according to physics, the two masses (or 2M) will move away (touching each other) at half-speed, or at V speed. What about the kinetic energy? Before the collision, the kinetic energy of M at a velocity of 2V equalled $(\frac{1}{2})$ (M) $(2V)^2$, or $(\frac{1}{2}M)$ $(4V^2)$ or $2MV^2$. After the two bodies collide, each will move at a speed of V, and the kinetic energy of each will equal $\frac{1}{2}MV^2$. The kinetic energy of the two of them equals twice $\frac{1}{2}MV^2$, or MV^2. The kinetic energy of the two bodies is now MV^2, and when this is compared to the energy of $2\ MV^2$ before the collision, it proves to physicists that one-half of the kinetic energy (or MV^2) is to be accounted for in terms of other energy-phenomena. This principle, they say, is true of every collision of solids, and unless this accounting can be made kinetic energy has been destroyed without compensation in mechanical terms. Such a destruction of energy, however, they contend, is impossible.

A moving body, however, has an attribute different from kinetic energy, and this fact introduces a complication. Momentum is also derived from movement. A body is supposed to possess momentum in some fashion that is independent of its kinetic energy. Momentum varies directly with the mass (m) and velocity (v). The general formula of momentum, therefore, is mv, and a body M moving with a velocity of 2V has a momentum of 2MV. The statement that a body has a momentum of 2MV, however, signifies nothing, it is said, in respect of the amount of its kinetic energy, yet it does seem to indicate that some kinetic energy must be potential in respect of the direction of motion. Thus a body of 100M, moving at a speed of 1/50th of V, has a momentum of (1/50V) (100M), or 2MV, but its kinetic energy equals ½ (100M) $(1/50V)^2$, or 1/50th MV^2, or only a one-hundredth part of the kinetic energy of $2MV^2$ possessed by the mass M when moving with a velocity of 2V. Here we have a case of two bodies each having the momentum of 2MV and the kinetic energy of the one is a hundred times as great as the energy of the other.

Let us now refer to case A. Before the collision, one body has neither motion nor momentum; whereas the other, moving at 2V velocity, has a momentum of 2MV. After the collision, the two bodies, or 2M, move together at a velocity of V, so that the total momentum still equals 2MV. We perceive, therefore, that half the kinetic energy of the moving body is to be otherwise accounted for in a collision wherein none of the momentum, or "charge" of motion, is lost. Half the ability to do the work, half the power to make other bodies move is supposed to have gone into energy-radiations at a time when the full "charge" of momentum (or motion) of the two bodies has not been decreased. Momentum is not *bona fide* energy, then, as kinetic energy is, for the kinetic energy may leave two bodies while the momentum remains. It would seem therefore, that if momentum is a kind of force, kinetic energy is not. At any rate, the two do not measure the same kind of force; for if they did, one could not be dissipated while the other remained. Perhaps, then, there are two kinds of forces, both arising from the motion and inertia of matter. Must we imagine this?

Can the force of momentum, this MV, be created from nothing? Or is momentum not a force, but merely a name? If it were really a force, how could it be created from nothingness? But is it thus created? According to mechanics it is; for when M collides at 2V speed with a motionless M, as in case A, the momentum remains 2MV in the two bodies, yet energy-radiations account for half the kinetic energy. Radiant energy, however, has momentum, as experience proves, so that when the momentum of the radiant energy is added to the momentum of 2MV it is found that the total momentum is increased by the collision. An impossibility seems here to be possible—that is, if one thinks that momentum is really something, and that energy does radiate from the collision of solids.

Suppose, however, that one denies that there is this radiant energy from the collision, and does not try to account for the lost kinetic energy. Certainly he may then say simply that the ''charge'' of motion, or force, or energy, possessed by the one body before the contact is now shared in full measure by the two bodies. If we believe this latter and simple proposition, however, we cannot believe in the axiom of physics quoted from Kent. To believe in the teachings of physics our imagination must be almost infinite. As Professor Whitehead puts it: ''The eighteenth century opened with the quiet confidence that at last nonsense had been got rid of. To-day we are at the opposite pole of thought. Heaven knows what seeming nonsense may not to-morrow be demonstrated truth.''[1]

There is something odd in this concept that the kinetic energy of a body is different from the ''charge'' of motion that a body has, and that the quantity of movement of mass (the total mv) can be increased without reference to the amount of kinetic energy. And why should kinetic energy vary as the velocity squared? Is velocity squared (v^2) the real measure of real force? And what does one really mean by the multiplication of a velocity by a velocity? When we multiply two numbers we virtually perform an addition in which we aggregate the value of the second number the same number of times that there are units in the first number. But how do we multiply a velocity by itself? Can one multiply a house by a house? Passing by this difficulty, how may we suppose that a thing squared, and not the thing itself, might be the measure of a basic principle, like force? Surely, as we observe the paradoxes in these rules, we shall be led strongly to suspect that the formula of kinetic energy is itself nothing more than a broad generality—fairly appropriate as an averaging formula, perhaps, but having no relationship to the unit-event.

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[1] A. N. Whitehead: *Science and the Modern World*, p. 166.

The moving body M of case A has had a single collision, and there is a certain result. Let us suppose that after the collision the double mass now (2M) comes into contact with still other inelastic bodies, all of mass M. In the next collision, the total moving mass will become 3M, and the speed will again be decreased in an inverse ratio to the mass, but the momentum will remain 2MV, and more of the kinetic energy must be accounted for in heat-radiations. We may conclude that the velocity may be reduced by successive collisions to as small an amount as we please, and the kinetic energy left in the bodies may approach zero as closely as may be imagined, yet the momentum of the bodies will remain forever the amount it was in the beginning. This being true, the smallest mass, moving with the least velocity, can never be brought to rest by colliding with any number of other inelastic bodies provided that none of the struck bodies is moving in opposition to the striking bodies. As the striking mass picks up other motionless masses, its velocity will more and more closely approach zero, but zero velocity will never be reached, and the momentum of 2MV will never be reduced. A moving body can be brought to rest, therefore, *only by receiving the blow of a body moving in opposition to its motion.* This is the same law that has been stated before—namely, the "charge" of motion which a particle receives from an exterior power can be cancelled only by an opposed "charge" of this same exterior power.

Let us now inquire into the nature of the force which absorbs the kinetic energy of a solid body as it is brought to rest. One would naturally suppose that the same sort of energy would be consumed in retarding a moving body that the body itself possesses. Physics, however, teaches otherwise. Kent (p. 536) illustrates the head-on collision of a body of ten-pound-mass moving horizontally at twelve feet a second with a body of eight-pound-mass moving at fifteen feet a second. As 10 × 12 equals 8 × 15, the momenta of the two bodies are equal. The kinetic energy of the ten-pound-mass, however, is 720 foot-pounds, and that of the eight-pound-mass is 900 foot-pounds. In such a collision, therefore, if the effects were delivered on the basis of kinetic energy, the eight-pound-mass would override the movement of the ten-pound-mass, and would push it back with a surplus of 180 foot-pounds. According to mechanics, however, the two momenta are here the forces which are in opposition, and they are equal, and since the bodies come to rest, the entire 900 and 720 units of kinetic energy in the two objects respectively must be dissipated in radiations or be accounted for in shifts of parts. Here then we have a picture of a smaller, kinetic energy balancing the effect of a larger. It is not explained how this can be so.

The moving forces balance here on the two bodies, at least, in terms of their mv, and not on the basis of their $\frac{1}{2}mv^2$. Indeed, kinetic energy would seem to be destroyed here, but the physicists escape this difficulty by stating that all the kinetic energies of the two bodies are dissipated in radiations. We must assume also that more of the radiations occur in one direction than the other, for more energy existed before the collision in the direction in which the eight-pound-mass was moving. In any event, the formula of momentum measures the forces which here, by their oppositions, bring about a cancellation of the motions of the two objects. In the case of the ballistic pendulum, also, it is assumed that the force or energy of the moving bullet is delivered as a product of its mass by its velocity, and not as kinetic energy. In this case, too, a greater kinetic energy is supposed to be resisted and dissipated by a lesser. Yet this seems incredible.

We might use our imagination and suppose that the kinetic energy of 720 foot-pounds in the eight-pound-mass might meet and resist and deflect or dissipate an equal amount of energy in the ten-pound-mass; but if kinetic energy is anything real we do not see what opposes and dissipates the excess of 180 foot-pounds of the total of 900 foot-pounds of energy in the eight-pound mass. If kinetic energy were anything real of itself, this amount of energy would surely remain after the collision uncancelled, and to be expressed in the direction in which the eight-pound-mass was moving; and then the two bodies would not be at rest, but would move on.

Such are the difficulties arising from a faulty premise. And when we treat of momenta, if we still assume that kinetic energies are something that are independently real in the sense that they can be dissipated as radiations, we are still in a predicament, for when we attribute momenta to these radiations we discover that we have not destroyed all the momenta in the head-on collision of the example just given. At least we may say that if the original momenta are cancelled in the collision new ones have appeared. If, however, we should assume that the radiated *momenta* are the momenta that existed in the bodies before their contact, then we do not explain the persistence of all momentum in the parent-bodies when one body strikes another at rest as in case A. In case A, radiations are supposed to occur after the collision and yet the original momentum in the direction of motion persists in full measure.

The kinetic energy formula leads us into absurdities, and we are convinced that the mechanical axiom which is supposed to apply to case A is incorrect. Only one postulate will permit us to escape the paradox—namely, the assumption that opposed energies can and do destroy each other without mechanical compensation. We are firmly convinced that single solid bodies never influence one another according to the formula of kinetic energy, and that this formula does not apply to the energy-unit of which all composite energy is compounded, but merely summarizes approximately a few of our grosser phenomena. Real energy can be delivered, we believe, only in proportion to the momentum, or velocity, of a moving, solid, and unitary body. When a body seems to deliver an amount of energy which is disproportionate to its relative velocity, the total energy-delivery must somehow be altered by the unperceived and unrealized influence of other bodies which are then active in this particular environment. We conclude that in the earth-environment unperceived masses are here and there expressing their energies of motion (one at a time, as a series of momenta), and that these forces doubtless influence the formula of momentum and make it take on the conventional energy-form, a form approximately correct for interpreting the phenomena of composite elastic bodies moving at relatively slow speeds, but quite inappropriate for the unit-event. When momentum is destroyed in the collision of solids, unit-energy is destroyed, therefore, and the Conservation principle is breached. This amount of energy would cease to exist unless it was recreated by the influence of an ''absolute'' Power.

When two solid unit-bodies make head-on contact, motion, like a charge of electricity, passes from one to the other. This transfer of motion *must* be the unit of all energy-transfers. Unit-energy exists in a direct proportion to motion—not in a proportion to motion squared, as the formula for kinetic energy has it. Without motion there can be no energy-manifestation. The two are synonymous. When we say that ''energy equals motion'', the predicate is fully contained in the subject, and the subject in the predicate. The power to deliver unit-energy, therefore, should be directly proportional to the velocity, and the power of a composite to deliver energy is also proportional to the number of units of matter that it contains. The formula for momentum should be the foundational principle of every energy-transfer, and should always be usable provided that it is properly modified to suit all the energy-conditions of the specific environment. There should be no trouble, moreover, in modifying the formula to apply to any known state of affairs. Indeed, if we are sufficiently sure that unit-energy is directly proportional to simple velocity and to mass, the fact that under certain conditions the formula for momentum may be modified into the different formula of kinetic energy, should inform us as to the energy-conditions of our environment. We should thus be able to confirm or contradict the interpretations of conditions reached from a more philosophical and less empirical approach.

What environment *would* alter our correct formula for unit-energy to make it correspond with the kinetic energy formula? To answer this is our obvious problem. We shall find that the condition which makes the kinetic energy formula applicable to the earth is to be discovered in the presence of an energy-condition that general reasoning has already suggested,—namely, the presence of universal energy-expressions in all directions and in fairly balanced equilibrium. The formula for kinetic energy applies to such a pool-formation of oscillating particles, one in which there is an energy-balance amid general energy-movements, like that displayed by the water-molecules of a pool. The formula for kinetic energy can apply only if there is that general energy-expression in all directions which affords that balanced and uniform "elasticity", as it is called, that we do find and depend upon in all our relationships with the composite atoms and compounds. We shall prove this later when we discuss the special conditions surrounding our earth. We shall then see why this discovered earth-formula for energy is fairly accurate in general practices of our world-environment even though the formula for momentum is the true formula for isolated force-delivery.

In case A, when the moving M strikes the stationary one, no momentum is lost. Hence, if the true force of a mass is its momentum, we need not suppose that energy must inevitably be accounted for in shifts of parts or in heat-radiations. Furthermore, when we consider the two equal solids which make contact from opposed directions, we shall discover that true force may be completely destroyed without mechanical compensations.

Returning for a moment, however, to conventional physics, let us try to account for the kinetic energy amounting to

MV^2 which is supposed to leave the body M when it moves into contact with a motionless and solid M at a speed of 2V. If the two bodies are really rigid solids, and if we suppose that there might somehow be energy-radiations from true solids, these radiations totalling MV^2 must occur *instantaneously*—the instant that the contact is established; for, as already stated, the solids cannot vibrate internally, and cannot *become* hot. The radiation must emerge, therefore, in a formation with no wave-length whatsoever—in a sheet-like bolt of only one dimension. Here is another mystery!

According to the conventional theory, the heat-vibrations within a homogeneous body are uniformly spaced. One part does not long stay cool while the other is hot; and the heat-vibrations are not confined to certain portions. The heat-motions after collision of the two M bodies, therefore, cannot display an excess of radiant energy in one direction. Nor can the heat-energy be stored in particles vibrating internally in some unbalanced fashion, for the bodies would not be motionless after the collision if the internal energies did not balance. Even if it were possible to imagine that the solid body which was struck did vibrate internally in some more energetic manner, and gave off its excess heat gradually, we could not suppose that *balanced* vibrations would account for the lost kinetic energy of MV^2, for this amount of energy, according to the terms of the problem, must be lost *in one direction only*. Let us suppose, however, that heat-energy can be emitted instantaneously in every direction from perfectly solid bodies—an inconceivable proposition, and contrary to the definition of a solid. Even then we cannot account for the loss of kinetic energy in case A unless we suppose that the radiations occur altogether in one direction. There is evidence, however, that this is not the case.

The unrealities do not end here. Unless an accommodating etheric or electromagnetic "field" were present (a substance or "field" which the physicist invents for the sake of an explanation even when his experience cannot confirm its presence, nor his mind conceive its qualities), which was able to accept the heat-vibrations, there could not be heat-emissions. In an etherless world, the loss of energy in collisions could not possibly be accounted for in terms of heat-waves in ether. The presence of an inconceivable and unrealized medium of some sort seems to be a necessary assumption, however, if the conventional mechanical ideas are to appear in any way real. Ether, just by happening to exist near every place of possible collision, makes somehow possible a mechanical principle which otherwise would be unreal. We have thus reached the strange conclusion that the passive presence of an imponderable ether-body (or an equally unreal field of electric energy) is necessary in order that a mechanical formula treating of an activity and of a ponderability may possibly be true.

We observe also that mechanics gives no interpretation of the direction or velocity of these heat-radiations which are supposed to account for the energy lost in the collisions of bodies, inelastic or elastic. Having thus illustrated several of the difficulties in case A, let us pass to case B.

In case B, two equal solid masses (each with mass M) collide head-on when each is moving horizontally with V velocity, but in opposite directions, that is with a doubled velocity of 2V relative to each other. These opposed motions are taken in respect of some point of quietude—usually assumed to be some stationary point on the earth's surface. As we shall note later, the point selected has some bearing on the theoretical result of the collision.

The kinetic energy of each moving mass M is $\frac{1}{2}MV^2$, hence the kinetic energy of both masses before collision is double this, or MV^2. By referring to the principles given by Kent, we learn that after the contact the two masses will be motionless, and their kinetic energies of motion, as represented by their own movements, will have become zero. The two bodies together have lost an energy equalling MV^2, and if we rely upon the Conservation theory this amount of mechanical energy is to be accounted for either in radiations or in shifts of parts. As the two bodies have come to rest, the total momentum of 2MV has been destroyed also—unless, perhaps, it can be accounted for in the momenta of that which radiates—an assumption which is not considered in physics.

It may be argued, perhaps, that no real force of momentum existed before the collision, or ever exists. Indeed, the mechanists make use of just this idea when their theories appear about to contradict one another. Thus they call one of the momenta ''positive'', and the other ''negative''. Then they say that the two together may be regarded as zero, or as non-existent. Even this supposition is provisional, however, and true, according to this view, only when the momenta are measured in reference to some point of the earth taken as the point of quietude. And the mass-velocity (or momentum) of each body does exist separately and distinctively as a reality, as a real potentiality. Except for the collision, each body would retain its motion, its momentum, and its energy. And if one body were annihilated by Evolution, the momentum of the other would remain real and ''absolute''. Neither momentum depends for its reality upon anything other than its own being. The physicists consider both momenta as unreal measures of force merely because this belief makes it appear reasonable that they should cancel each other when they meet head-on. If they were sure that two opposed kinetic energies might off-set each other also (as a positive cancelling its negative), they might regard them also as non-existent because potentially self-cancelling. The physicists insist that a total momentum of 2MV is actually destroyed without compensation in the collision of case B, and that it ceases to exist.

Forgetting for the moment this theory of destroyed momenta in case B, let us consider the kinetic energy. According to physics, the entire energies of motions of the two moving bodies are dissipated by their head-on collision, and—neglecting the possibility of shifts of parts in solids—are to be accounted for in energy-radiations. The bodies have come to rest in reference to the centre of quietude, but, as in case A, they cannot be hotter than they were before the collision, for how can they become hot and yet remain inelastic solids? Even the physicists suppose that the two inelastic bodies remain in contact after collision, moreover, which would be impossible if either were vibrating. Hence, if they radiate energy, as is supposed, this radiation must take place instantaneously. As in case A, both the source and the nature of the radiations are mysterious. Unsolvable contradictions develop from this so-called principle. The practical everyday formulas and principles seem quite unreal when referred to the unit-event. If we now compare case A with case B we shall not be much surprised to discover that these principles are incompatible.

In case A, the striking particle *alone* loses kinetic energy. The struck particle does not lose, but only acquires, energy. The striker, therefore, is the *only* body which can radiate energy as an original source. As the radiation occurs immediately, the struck body will never be heated, but will merely accept the motion from the striker—and that instantaneously. In case B, both bodies come to rest, both lose kinetic energy, hence both are original sources of heat-radiation. This is the theory.

Here, then, is a difference between case A and case B that is supposed to be *actual*. In case A one mass radiates heat, and in case B both bodies give off these radiations. The results are distinguishable. One should be able to examine the two bodies after the collision and, if only one has emitted heat, be certain that this was an example of case A. Yet, what can one say of this supposed fact if it can be shown that there is no real distinction between case A and case B except that of *point of view?* Is it possible for case A to change over in mechanical result to case B merely because the point of view of the observer has altered? Can one set of facts be subject to more than one interpretation involving the reality of heat-radiations? No, this is inconceivable! There is only one collision, and, however it is viewed, the mechanical happening remains one actuality. If the axioms of physics as they relate to facts change as the point of view changes, there is some error in these axioms. One is certainly incorrect; and perhaps both.

We have taken a stationary point on the surface of the earth as a spot from which to measure motion. In respect of it the bodies in case A are both moving after the collision, and only one has given off heat, whereas in case B neither is moving, and both have radiated heat. This point of reference, however, is a point of quietude only in respect of the earth, for the earth is moving. If the collision of case A is observed from the sun both bodies will appear to be moving. And perhaps one body will appear to overtake the other in case B, instead of colliding from opposite directions as they appear to do when reviewed from a point stationary on the earth.

Each of two automobiles receive the same general effect from a collision, whether one is standing still on frictionless wheels and is struck by another rolling freely at twenty miles an hour, or whether they roll against each other freely from opposite directions when each is moving at ten miles an hour. The two collisions being identical, in so far as the meeting of the objects is concerned, both cars will be mashed equally, the same amount of kinetic energy will be lost by each automobile in each case, and the heat-radiations will be the same in both instances. As collisions, there is no vitally real distinction between the facts of the two events, yet the two collisions, according to physics, will have different relationships in respect of two arbitrarily selected points of reference, and, therefore, will display two different principles. We know that when only one car is moving before the collision, both will be in motion afterwards with reference to the ground, and we see an example of case A; but, when the two cars collide from opposite directions, all motion of the cars with reference to the ground ceases, and the result exemplifies case B. Yet, the answer to the question whether the motion of the cars continues or ceases after the collision, depends upon the selected point of reference. An observer on the ground sees the collision as case A, whereas the observer in another moving car will be justified in regarding it as an example of case B. If the automobiles were solid, then, would one or both lose kinetic energy, and would one, both, or neither, radiate heat?

It is illogical to regard the earth as an "absolute" centre of quietude. The earth moves about the sun at a speed of some nineteen miles a second; the sun and earth together move towards the star Vega at perhaps twelve miles a second; and, according to Professor Miller, who believes that he has identified the centre of our sidereal system, the entire solar system is moving in respect of what may be the universal centre of quietude at a speed of about sixty-four miles a second.

Although the physicists themselves cannot say whether any one collision should fall under case A or B, or in some other intermediate class, yet they suppose that two distinguishable phenomena of heat-radiations result from these two classes of earth-relationships. As the earth-relationship has no bearing on the facts in the case, there must be an error in the theory. Certainly, no formula is worthy of trust that makes the outcome depend, not upon the event itself, but upon the point of view of the observer.

From the beginning, the mechanical principles described under cases A and B have seemed incorrect. We have been willing to assume for the moment that elastic composite bodies of the usual experience might lose kinetic energy through radiations, but we have been sure that this law did not apply to inelastic solids. We have now become convinced that the formula of kinetic energy cannot be used to interpret unit-facts. The true principle of force-delivery, and the exact measure of the ability of a moving body to do work—whether we refer to the unit of matter or to aggregations of it—is to be measured, we are sure, only by the formula of momentum. All force is delivered in a ratio to the amount of motion or velocity that a mass has. The true energy of a moving body,—*i. e.,* its ability to make other bodies move,—when moving in free space and uninfluenced by environmental conditions, must be determined as *momentum.* When collisions occur between solids moving in directions opposed in respect of the universal centre of quietude, momentum is destroyed, and is not otherwise accounted for. And, since momentum is the measure of real energy, real energy is destroyed in such collisions, and is not accounted for in heat-radiations.

The usual formulations of physics are nothing more than approximate working rules for the usual earth-conditions.

They lead to erroneous concepts when we attempt to use them to prove anything about the delivery of unit-energy, or about the delivery of any quantity of isolated energy, or about the Conservation of motion. These work-formulas, because they are often assumed erroneously to interpret basic principles, are supposed to be capable of proving that nothing ''absolute'' or significant can happen in the universe. They are believed to demonstrate that mechanical Conservation reigns supreme. Truer knowledge would demonstrate the opposite. If momentum, or true energy, is destroyed in head-on collisions, then, because bodies move again, it is proved that significant and ''absolute'' events are constantly taking place.

We have another reason for supposing that radiations cannot account for the forces lost in the collisions of two solid unit-bodies. It seems that when two bodies collide when moving at a velocity of only ten feet a second, the waves of energy radiate from the collision at enormous velocity. When our experiences deal with composites rather than with solid bodies, we have the right to suppose that their parts, like pendulums, are moving very rapidly; and our theory of a general energy-equilibrium makes us assume, too, that every part of a composite body is subject to the repeating blows of exterior bodies which are themselves moving at enormous velocity—perhaps the speed of light.

This, however, is not the conventional belief. According to physics, radiant energy is not induced by blows from the outside, but is in some way derived from the internal losses of kinetic energies due to the ''spontaneous'' movements of electrons in their atomic orbits. These atoms, however, are not solids, hence the mechanical theory of units does not apply strictly to them. How, then, when radiations appear at enormous speeds from the collisions of slowly moving solids, are they to be explained? Certainly, a body moving at ten feet a second cannot by its impact create the speed of light. The velocity of radiations from the collisions of near-solids seems to afford proof that the radiations cannot be due to the kinetic energies lost in the slow velocities of the usual collision.

It is incredible that a *perfectly* solid body should, by its own movement, generate in the direction of its movement a velocity greater than its own. It is unthinkable that the blow of an automobile, if all of its parts are moving at ten miles an hour, should by its shove create in the same direction the velocity of light—186,000 miles a second—or even of eleven miles an hour. Can a solid ball knock another solid ball on ahead of it faster than the striker moves? Can velocity be created out of nothingness? Do these radiated energy-waves correspond to none of the laws of Conservation? The speed of the radiations proves too that the bodies *were* elastic composites, and not solids.

There are still other inconsistencies. How can energies be radiated in full force from colliding solids at an angle perpendicular to the direction of the meeting? Yet most radiant energies from colliding objects do move in directions perpendicular to the line of original motion. Surely, if the original motion alone caused the energy-radiation to be emitted, this result would be impossible! Let us ask, too, how a mass M, by striking another motionless solid at a slow speed, can cause a rebound of energy at an enormous speed? If this were possible, we must needs abandon the seemingly valid principle that motion in one direction cannot be stopped except by the receipt of motion in the opposed direction.

Let us suppose that two solid bodies are alone in space, and are unaffected by the presence or motion of other masses or powers. Then, if there were no parts moving inside of either of them, if both were really solid, it would be impossible that there should be radiations of energies from them with velocities greater than the speed of their own movements up to the point of collision. If the piston of an engine is moving forward in the cylinder at a speed of fifty miles an hour when an automobile collides with a tree at ten miles an hour, this piston might be released into space, and might continue to travel forward at its own speed, and therefore faster than the ten miles an hour of the automobile, but certainly it could move no faster than its own velocity. Also, if the parts of the atoms composing the piston were really moving like pendulums in every direction at the speed of radiant light or heat, then, through the release of the collision, some of the parts might radiate in various directions with these enormous speeds—but not otherwise. In the relationships of two colliding solids, however, there is no such oscillation of interior parts. Furthermore, in treating of the energies of the collisions, we are not considering the internal energies of the molecules of the separate bodies, but are referring only to motion of the moving objects as such.

Every physicist must admit that there are puzzling features in the conventional theory. The radiations manifested by heat and light, it would seem, must develop from conditions pertaining to the separate parts moving within the parent-bodies. No such radiations, however, can possibly come from the collisions of otherwise uninfluenced and completely inelastic solids. The formula containing this unreality has been accepted because we have never had experiences with real solids, or with objects isolated from an environment of energy-impulses. The collisions interpreted by our formulas have taken place in a pool of pressures, a pool even maintained as to its local pressures by other pressures exterior to it. When, therefore, we deal with the theory of the collisions of isolated solids we find that our conventional formulas—and the principles to be deduced therefrom—are erroneous and misleading.

Physicists assume that the momenta of two solid bodies moving in opposition, as in case B, cancel each other. Why is it necessary that we should think of kinetic energy as indestructible at a time when one momentum is being regarded as positive and the other as negative, and the two together as self-cancelling? Is there some magic in $\frac{1}{2}v^2$ that does not refer to plain v, so that the laws of the $\frac{1}{2}v^2$ do not relate to the v? This seems unreal, yet precisely this assumption is made. But, after all, momentum is the real measure of force. As we shall see later, momentum gives motion to the ballistic pendulum. Momenta in the drops of water also support the weight of the ball on its spray, and the momenta of air-particles drive the sail-boat. Even in physics, momentum is sometimes recognized as a real force—as real as the force that balances weights on a lever. Yet it is presumed that this reality can be destroyed by collision without danger of a breach in Conservation!

When M moves with a speed of 2V, it is supposed to possess a kinetic energy which equals $\frac{1}{2}M(2V)^2$, or $2MV^2$, inevitably, and regardless of the surrounding conditions. This is an unequivocal statement. We are led to ask, however: "Can it be supported by reason?" Are there no exceptions? May it not be possible that the theory is true only of some particular condition—namely, that which comes under the usual observation? And may it not be somewhat incorrect even for these experiences?

We have now reached the conclusion that momentum is the true measure of all force-manifestation, and that kinetic energy merely formulates special conditions wherein many momenta are consumed. Nevertheless, we are confident that momenta may be cancelled in head-on collisions, and we assert as a necessary conclusion that wherever momentum *is* destroyed without being accounted for, true energy is destroyed, and that the Conservation doctrine is to this extent proved inaccurate. We do not doubt that in many collisions of elastic bodies a great deal of radiation occurs—not to begin with as waves of pure energy in ether, but as the unusual energy of moving masses, (or mass-vibrations) passed on unusually to the surrounding pool of matter. To judge intelligently whether momentum (real energy) is destroyed in a certain collision, we must first identify the "absolute" centre of quietude of the finite universe, or at least the centre in respect of which it is re-created. Without such a point of reference, statements concerning the destruction of energy are meaningless. In respect of some arbitrarily selected point of reference, motions may seem to be opposed and self-destructive, whereas the same motions, if taken in respect of some other point, may appear to represent the case of a slow-moving body being overtaken by a faster. When a fast body overtakes a slower while both are moving away from the "absolute" centre of energy, motion has not been destroyed by the collision, but has merely been *averaged.*

Even, however, if momentum (as seems unquestionably to be the case) is the sole force-principle that, in multiple, adds velocity to a body existing by itself in empty space, it is inadequate for use as the measure of the force required to establish the continued movement of a body through a balanced energy-pool of corpuscles. The formula of momentum, although correct as the principle of *unit* energy-transfer, will doubtless be insufficient for measuring the total amount of energy required to shove an ocean-liner through water with a sustained velocity. The momentum-formula will apply for only the smallest part of a second to motion through such a pool. It cannot therefore be used without modification in regard to any sustained motions in the universal pool of pressures which, according to our theory, exists about us.

The procedure for proving that both these theories, the one concerning the nature of unit-energy, the other concerning the universal energy-equilibrium, are correct, now seems obvious. Let us accept them as realities, use them as the premises of our reasoning, and develop the practical working formulas which *should then obtain,* and see if they conform with reality.

The kinetic energy formula, although unreal in itself, we say, and untrue of unit-force, has nevertheless been proved practical for some of our experiences in the large; hence it is essential that our reasoning should develop from our premises, not some entirely new formula for kinetic energy, but approximately the one we are now using. We must derive from our assumed conditions almost the very formula for certain types of gross usages that we have been inclined to disparage as a principle of theoretical value. Then, having made this demonstration, we shall have almost conclusive proof that both premises are sound; and we shall have confirmed the fact that momentum is the measure of unit-force. We shall then be justified in asking the physicists to admit that when momentum is destroyed without compensation *real energy is destroyed.* This, indeed, is the important, the most important philosophic aspect of our argument. We are trying to demonstrate here in the heart of mechanics that energy is cancelled without mechanical compensation in the collisions of solids. Here we are proposing to clinch our mental theory with mechanical nails.

We have now proved in several ways the reality of the free-will of the general mind-power in its relations with matter. We believe that we have proved it adequately in philosophical terms, and we now expect to make use of the axioms of physics to show that motion in reference to the centre of this finite universe is "absolutely" destroyed in every collision of bodies moving in opposed directions as regards the centre. We hope thus, once again, to demonstrate the reality of the mental Power which causes the cancelled energy again to be expressed. Indeed, we feel that this principle has already been fairly proved. Perhaps we need not make the effort of deriving the formula of kinetic energy as that special case of the momenta-relationships which applies to sustained motions in a pool of balanced matter-pool. We feel confident of the conclusions already reached, but, to be doubly sure, we shall, in the next chapter, make this demonstration in a way that seems final. For the moment, however, let us continue the discussion of collisions and radiations.

We have agreed that, when composite bodies collide, radiations may occur, but these emanations do not appear to account for the kinetic energy lost in the contact. Certainly these radiations are supposed to emerge in every direction, yet how can such emissions account for the lost kinetic energies of the colliding bodies? In case B, only radiations with components having an average expression in the directions in which the two masses moved before collision can account for the cancelled energies of motion of the objects. Yet, as we have said, the emissions are largely in directions perpendicular to this direction. Let us therefore ask a question of the physicists: What kinetic energies account for the radiations (and components of radiations) which *are* expressed perpendicularly to the line of collision? What can be the source of such radiations when there are no losses of kinetic energies in these directions by the moving bodies to account for them? If, however, some radiations are not accounted for in mechanical terms as the dissipated energies of motion of the moving objects, why should others be thus interpreted?

And, if the radiations perpendicular to the direction of motion represent real kinetic energies, whence do they come? Out of nothingness? If so, why may not other motions disappear as readily into nothingness?

We are confronted with many puzzles when we try to account for the lost kinetic energies of case B on the assumption that radiations emanate from true solids, or in terms of energy-radiations created by the motions of the solids themselves. It seems obvious that most of the energies of heat-radiations are due to the influences of the environment—just as the so-called self-perpetuating "thermal motions" of gases are themselves really due to exterior impulses.

A modern writer, Dr. M. Luckiesh, illustrates some of the difficulties of explanation encountered by modern physicists:

> When Maxwell developed the electro-magnetic theory of light he still needed an ether as a carrier of the waves. The laws which he developed are straight-forward and simple, but his ether model was complicated and of very special properties. However, with the introduction of electric and magnetic concepts these began to claim attention and the difficulties of mechanical interpretations of the ether were gradually *more or less ignored.* But this lack of attention to the mechanical model did not eradicate the *difficulties and the unsatisfactoriness.* There was a tendency to explain mechanics in terms of electro-magnetic principles. This seemed to be a way out, nevertheless it *was not successful.* Matter was finally supposed to be a bearer of electro-magnetic fields and inasmuch as such fields are found in a vacuum, the ether had to have the properties extended. Always ether possesses functions of ordinary matter, therefore it grew more complicated as the properties of matter were extended.[1]

According to Dr. Luckiesh, "Einstein credits Lorentz with having taken from the ether all mechanical properties except immobility."[2] And then he says, "The controversy still rages." "Einstein's view is, that it is inconceivable that we can ever detect any motion between matter and ether, but this does not mean that there is no such medium.'' The extraordinary confusion of ideas experienced by modern scientists as they try to reconcile their facts and their formulas with the erroneous premise of Conservation is disclosed in their many conflicting views.

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[1] M. Luckiesh: *Foundations of the Universe,* pp. 69–70. Italics mine.
[2] *Ibid.,* p. 70.

Einstein, in his general theory of Relativity, assumes that a ray of light possesses something that is the equivalent of mass. According to Dr. Luckiesh, Max Planck, the originator of the quantum theory of energy-radiations, ''used the electric charge (electron) in the atom as a source of radiation, and concludes that it, which he calls an *electric oscillator,* or *radiator,* emits light *discontinuously;* that is, in elemental quantities which he called *quanta.* Each radiator can emit only whole *quanta.*''[1]

This theory of Planck pertains directly to the problem of heat-radiations from the collision of unit-solids, and confirms again our belief that it is impossible for solid bodies to give off heat-radiations. To us, Planck's theory means that the unit-solid is perhaps that quantum of mass which displays the quantum of energy. The quantum *must* be the unit of mass and of energy, and inter-atomic velocities must be uniform if all energy-radiations really do occur in exact multiples of a quantum of energy, for, as we have already observed, the unit of mass is doubtless different from (but it is not to be distinguished from) its energy-effect. It is recognized only in terms of its energy-effect. When two large composite bodies collide, many of their quanta-parts will doubtless deflect from one another, and break loose from the structure. They will then be radiated in the form which we recognize as heat-or-light-energy. The important point is this: Radiations of quanta can originate only *from bodies larger than the single quantum—that is from composites.* Therefore, quanta-radiations cannot possibly be derived from the collision of the smallest bits of matter—that is, from the true solid.

Let him who doubts this ask what would happen if two quanta collided? What sort of radiation could be derived from such a collision? Surely, when these two tiniest of bodies collide, it is inconceivable that these units (quanta or what not) might themselves be emitted so as to account thus for the lost energy (or motion) of the collision. If we accept the theory of Planck, therefore (and it has been rather generally accepted), we perceive that the mechanical principle of radiation does not apply unless the body is larger than the quantum mass which delivers the quantum-quantity of momentum when moving at a certain speed.

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[1] *Ibid.*, p. 129.

It has been calculated that the smallest area detectible under a microscope could be represented by a single layer comprised of 30,000 atoms, and the space occupied by the single electron is an incredibly small volume. The nucleus of an atom is supposed to occupy a space about one-millionth of a billionth of an inch in diameter, and a molecule (the atom of elements, and the unit portion of compounds, and itself a composite) is so small that if all the people on earth—approximately two billions—should count 100 molecules continuously each minute, it would take them 100 million years to count the molecules in a single ounce of hydrogen gas.

Now the total effect of any head-on collision of composite bodies, in theory at least, should be calculable as the sum of the effects of the collisions of their tiny parts. In practice, however, this calculation will be incorrect, for, although the separate contacts take place solely between units, comparatively few collisions of units will be exactly head-on. An incredibly small number of quanta (or smallest bodies) will meet squarely in non-deflecting opposition, and this assumption is particularly reasonable if the units are spheres. Radiations of units (or quanta) are to be expected, however, when two large atomic structures collide, but this fact in no way affects the argument that motion (and its energy) is actually destroyed, and cancelled without compensation, whenever these tiny, inelastic bodies themselves happen to meet in opposition.

Only a very small percentage of the mass of parent-bodies is emitted when they collide. Only those pendulums depart from the structure permanently whose supporting threads are broken. The energies of their departure, moreover, do not refer to the velocities of the parent masses. Thus, although the principle of physics may be quite erroneous in so far as it relates to units; although it may be quite incorrect as a foundational law of energy-transmission; nevertheless, in actual practice, the results of collisions of bodies of certain structures are fairly uniform. We are assured, however, that when the collisions of solids occur, there are no shifts of parts, there are no radiations of heat or light, and all of the motions and energies of these unit-bodies are destroyed without mechanical compensation. And we realize at the same time that most of the momenta (energies) of the colliding composites are destroyed by the collision.

Because these proved formulas of practice apply to our experiences (not exactly, but closely enough), we have been led astray. We perceive now that if matter-particles, when moving in opposite directions as regards the centre of the universe, can collide and then move again with their former ''absolute'' motions as regards this central point, some outside power must re-create their movements. This must be true, at least, if the universe is finite.

Dr. Luckiesh remarks that ''Einstein assumed the universe to have a finite volume, although it was unbounded.'' He then says, satisfactorily enough, that ''Doubtless, the reader, if he has not already deserted, will weaken at this point.'' We do weaken when we learn that if we are to keep up with Einstein's imagination, we must somehow imagine a finite though unbounded universe.

If the universe is infinite, it has no central position in reference to which an omnipotent power might cause matter to move in ''absolute'' fashion and for the accomplishment of an ''absolute'' purpose. Thoughts concerning the significance of motions within a finite universe *are* reasonable, for motion created or destroyed with reference to its centre is an ''absolute'' change in its energy-manifestation. Unless the universe is finite, we cannot distinguish between the collisions of cases A and B. A universe, however, that is both finite and unbounded, lies farther in the haze than our imaginative vision can reach.

It seems evident, therefore, that the question of ''absolute'' motion or ''absolute'' quietude cannot be determined unless one is able to locate the unmoving centre of mass-movements. Only motion taken with reference to it is truly ''absolute''. Unable, thus far, to determine the position of this centre, we cannot say of two bodies that one is truly at rest, and that the other alone is moving. It is never known, therefore, that case B certainly applies to a collision. ''Absolute'' motion, as thus defined, has not been determined nor measured.

Although the worthlessness of the usual opinion as to ''absolute'' motion must be admitted; although we cannot tell in any one particular case exactly what the truth is, nevertheless we may still say positively that in *some* cases of head-on contacts between unit-particles ''absolute'' motion is completely destroyed, and that then a complete breach is made in the Conservation doctrine. Thus far the physicist has been inclined to throw this breach of Conservation into the hazy realm of heat-motions and of ''spontaneous'' radiant energies. They do this even though heat-motions cannot be explained in terms of Conservation, and although true solids have no possibilities of being hot or of giving off radiant energy from themselves.

If the universe is finite, furthermore, then at its bounds a transcendent power must halt and reverse the motions of the particles of matter that are moving away from its ''absolute'' centre. Only by such restraint can the universe be held within limits, and only thus will the matter within it be kept in a fairly consistent space-relationship. The motions, the collisions, and their results, will all be due, we *must* then suppose, to the influence of this mental Cause that is having its powerful way with the universe. As regards the universe as a whole, we would apply the definition of free-will given by Nietzsche: ''Freedom of Will is the emotion of supremacy in respect to that which must obey.'' The universe of matter obeys the universal Will!

It behooves us now to make the final proof that the ''absolute'' ability of a body to do work is proportional to its velocity or ''charge'' of motion. Real mechanical force, the unit of all mechanical force, that which relates to bodies moving separately in space, is to be derived, we maintain, as a function of mv, and not of $\frac{1}{2}mv^2$. It must be proved, therefore, that the formula, e equals $\frac{1}{2}mv^2$, is approximately true only of certain gross states of affairs—conditions, however, that ordinarily obtain within this universe. Indeed, it is the usual presence of those conditions that gives the formula its practical value.

If we can prove this, we shall not only have identified the reasonableness and practicability of the usual formula of energy, but, what is more important, we shall have reached a better understanding of general conditions. With this demonstration made, we should interpret confidently the surroundings; and then, knowing the environment of our earth, we may reach definite conclusions concerning the Evolution that everywhere proceeds within it.

The discussion of these principles of physics,—which possibly has seemed out of place in this work—may, after all, be the entering wedge which will open a clear vista of the spiritual through the shadows of the material. By proving the fact of the Involution of Matter, we may demonstrate the Evolution of the Soul. If we can reconcile the facts of physics with the facts of Evolution, we shall have made a good start in entering this wedge, and in making this demonstration.

CHAPTER XXI

COMPARING MANY DEFINITIONS OF MECHANICAL TERMS

> The sheer statement of what things are, may contain elements explanatory of why things are.
>
> A. N. WHITEHEAD.

What is Force? Energy? Momentum? What is the Moment of force? What definitions will present the meaning of each and permit us to comprehend their connections? Are there such connections?

Physics does not state the relationship of momentum with energy. No explanation is advanced for the difference in their numerical summations. Formulas, but not their logical derivations, are provided. We are told that a moving mass expresses both momentum and kinetic energy, and that momentum, or force-time (Ft), is measured as a direct proportion of mass and velocity (mv), whereas kinetic energy, or force-distance (Fs), is summarized as one-half the product of the mass by the velocity squared ($\frac{1}{2}mv^2$). Kinetic energy is described as the ability of doing work possessed by a body in virtue of its motion. A sled, just before starting down a hill, has potential energy; at the bottom of the hill, when it has acquired velocity, it has kinetic energy at least in reference to the earth. A moving bullet has kinetic energy, it is said, since it will do work (in reference to the earth, again) when it is brought to rest. Indeed, all moving masses possess this sort of kinetic energy; but the bullet, the moving sled, and other moving bodies also possess momentum. "There are two kinds of energy," one says, therefore; but is this really so? Exactly what, in respect of force, is momentum? Does momentum do work? Are momentum and energy related?

If the velocity (v) of a unit body (m) is taken as one foot a second (1), the momentum will be mv, or (m)(1), or m; whereas the kinetic energy will be $\frac{1}{2}mv^2$, or $(\frac{1}{2})(m)(1^2)$, or $\frac{1}{2}m$. We note that the numerical value of the momentum (m) is twice as great here as the kinetic energy ($\frac{1}{2}m$). We observe, too, that both momentum and kinetic energy increase as the velocity increases, but that they do not increase in similar ratio. When the body is moving at two feet a second the momentum is calculable as 2m, and the kinetic energy as $(\frac{1}{2})(m)(2^2)$, or as $\frac{1}{2}(4m)$, or as 2m also. Here the two formulations—both expressed in terms of mass and motion,—equal each other numerically. When the velocity is three feet a second, however, the kinetic energy is calculable as fifty per cent. greater than the momentum, for the kinetic energy then figures as $(\frac{1}{2})(m)(3^2)$, or as $4\frac{1}{2}m$, whereas the momentum is only 3m. As the velocity continues to increase the numerical kinetic energy-value increases much faster than the momentum-value.

Let us now compare the figured values of momentum and kinetic energy for a velocity which is taken, first as one yard a second, and then as the spatial equivalent of three feet a second. When the velocity is regarded as one yard a second the momentum has a numerical value twice as great as the kinetic energy; whereas if a yard is regarded as three feet, the number representing the kinetic energy is fifty per cent. greater than the momentum-figure. This seems strange. Why should there be this difference in the ratio of these numerical values when there has been no change in the real velocity, but merely a change in the values of the numerical unit describing the velocity? We shall discuss this question in the next chapter, merely introducing it here to prove that there is such a problem. Indeed, the lack of constant relationship between the figured values of momentum and kinetic energy has inclined the physicists to believe that momentum is not a doer of work—not a real form of energy. Again, momentum can be destroyed in a collision, whereas true energy, it is said, cannot thus be destroyed. I shall attempt to prove that not only is momentum a form of energy, a doer of work, but that, even so, it may be cancelled by opposition, and annulled without compensation. The relation of momentum to kinetic energy, and the distinction between them, must both be clearly understood if one wishes to comprehend the fundamental facts of mechanics.

Professor William Kent defines matter as ''any substance or material that can be weighed or measured.'' Professor L. B. Spinney, in *A Text-Book of Physics,* tells us that ''the mass of a body is the quantity of matter it contains.'' We are left to form our own opinions about the nature of the ''matter'' which constitutes the ''mass.'' Professor J. Prescott, in *Mechanics of Particles and Rigid Bodies,* describes matter as ''anything which occupies space.'' Professor Ludwig Büchner, in *Force and Matter,* which was written in part to prove that neither matter nor mechanical force is destructible, does not define matter, but says rather incoherently that "Force and matter are fundamentally the same thing, contemplated from different standpoints.'' He remarks also, rather awkwardly: ''Hence we can say nothing except that matter, and therefore the universe, are infinite in minuteness, and it matters little if our reason, accustomed to find quantity and limit everywhere, should be startled by such an idea.''

The following absurd definition of matter is given by Hegel in his *Logic:*

> Matter is mere abstract or indeterminate reflection-into-something-else, or reflection-into-self at the same time as determinate; it is consequently Thinghood which then and there is,—the subsistence or substratum of the thing. By this means, the thing finds in the matters its reflection-into-self; it subsists not in its own self, but in the matters, and is only a superficial association between them, or an external bond over them.

Clerk Maxwell has said:

> We are acquainted with matter only as that which may have energy communicated to it from other matter, and which may in its turn communicate energy to other matter. Energy, on the other hand, we know only as that which in all natural phenomena is continually passing from one portion of matter to another.

In the standard work, a *Treatise in Natural Philosophy,* the authors, Sir William Thomson and Professor Tait, say that "the naturalist may be content to know matter as that which can be perceived by the senses, or as that which can be acted upon by, or can exert, force." More than twenty-five definitions of matter are given in this book, but Professor Tait writes in conclusion that "the discovery of the ultimate nature of matter is probably beyond the range of human intelligence."

The modern metaphysical physicist, in one sense at least, does not regard matter as having a constant mass as subject to measurement, at least except when it is relatively at rest. Mr. Bertrand Russell argues that "processes occur where there is no gross matter, and that these processes proceed, at least approximately, in accordance with Maxwell's equations. There does not seem any necessity to interpret these processes in terms of substance; indeed, I shall argue that processes associated with gross matter should also be interpreted so as not to involve substance."[1] Again, he says: "There are two kinds of Mass involved in physics, of which one may be called the 'invariant mass,' the other the 'relative' mass. The latter is the mass obtained by measurements, when the body concerned may be moving relatively to the observer; the former is the mass obtained when the body is at rest relatively to the observer."[2] Mass and energy, according to him, are amalgamated, and the two different kinds of mass are related to each other in a ratio which involves the velocity of light. Mr. Russell never specifically defines matter, or gross substance, or that which has variable mass.

Now it seems quite unnecessary that we should consider here the bewildering hypotheses that have been developed in the shadow of the Relativity theory, for their influence on ordinary mechanics is slight, and in the relations of every day even the Relativist will admit that, whatever matter is, the earth-elements may be treated as if constant in quality in reference to our frame of reference, and as if unaffected by the usual motions. Mr. Russell's invariant and relative masses are outside the scope of this chapter. Even if this theory were true, it would not affect our reasoning. The definition of matter given in an earlier chapter is sufficiently explicit, I believe, for the explanation that is here undertaken.

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[1] Bertrand Russell: *The Analysis of Matter,* p. 121.
[2] *Ibid.,* p. 122.

The definition of inertia, furthermore, is implicit within that of matter, for inertia (at least when taken in respect of one frame of reference) is revealed as the essential property of the material unit. In saying that the rigid unit of matter has inertia we merely repeat that part of the definition of the unit which implies that when a stationary mass is struck it will accept part of the motion rather than share its space-volume with the moving body. The struck corpuscle prefers normally to move on ahead of the striking one rather than disrupt as matter. This cohesion of the unit is the final measure and limit of its inertia. If the cohesion of the solid unit, the smallest particle, should be broken by the force of the blow, then its inertia will disappear, the unit will become less than the smallest bit of matter; and the former piece of substance will no longer exist with its old set of unit attributes. A new collection of qualities will then be manifested; and these must be thought of as non-material, for they do not pertain to the properties of the unit of matter. The rigidity, solidity, and inelasticity of the unit matter-particle are *limited* properties, after all, and are neither necessary nor permanent. This concept of matter is at least understandable. Whether it contains truth can be decided only by determining whether or not the facts of experience may be explained in accord with it. We do not believe that the inertia-property of mass can be destroyed unless the reality of the matter itself is destroyed.

Now let us consider the conventional definitions of Force, Energy, and Momentum. The reader will soon perceive that they are not very clear; and he will find it hard to correlate or synthesize the knowledge gained.

Professor Kent defines force as "anything that tends to change the state of the body with respect to rest or motion." This definition would seem to include the effects that may be given both by momentum and by kinetic energy. It involves motion, velocity, space, and inertia. What, then, is force? The conventional unit of force is the weight of a pound—the force that is able to create an acceleration in a pound-mass within one second of 32.2 feet a second. A strange unit to take, one would say, without explaining how or why—for how can a unit of measurement be acceptable which has no fixed value of its own? Here the value of force depends upon an undefined space-and-time-interval.

The force of a weight is supposed to be continuous; and yet its effective value varies with the passage of the moments, for weight-force will create more velocity in two seconds than in one. Is there any part of a second, then, one may ask, in which the weight of a pound-mass will express no force? If the force of weight should be granular, as we strongly suspect, there should be intervals during which this unit of weight-force will be non-existent as a velocity-creating agency. Certainly this is an anomalous situation. And it complicates matters when we introduce what is usually supposed to be a continuous force—and yet a force which *is* cumulative through time (this, also, an anomaly)— to act as the unit of force, and to act as if it were a constant, and to take part in a number-system. After such a beginning the ideas of physicists have necessarily become confused. How can we expect to understand exactly what our numerical formulas involving force mean when we do not even understand that which we take for the unit or "one" (1) of force; when we tie up our force-principle with extended space and with the flow of time; and when we suppose that the unit of force can be repeated continuously, and still be incorporated in a number-system? Nor do we seem to locate the source of that power which gives bodies their structure, their elasticity, and their ability to cancel momentum. Our formulas are derived almost entirely from gross and somewhat inexact experiences, and we understand the "why" of hardly any of our rules.

Beginning with the unit of force (which, after all, is not a unit-reality, but a combination), Professor Kent defines inertia as "that property of a body by virtue of which it tends to continue in a state of rest or motion in which it may be placed until acted upon by some force.'' Velocity (a combination also) is defined as ''the rate of motion, or the speed of the body at any instant.'' In terms of what units, one asks, is this speed to be measured—what unit of distance and what unit of time? There is no answer. How can the units of distance and time be defined so as to fit suitably into the formulations of mechanics when the force-unit itself is supposed to be continuous in time, and without separated parts? How can an energy-expression act as a unit if it cannot be cut up into unit parts? Nevertheless, these formulas, unreal as they seem, are satisfactory for most of our everyday practices, and the physicists seem to think that the practicality should satisfy even the most exacting person.

The definition of momentum is vague also. Professor Kent says that ''the product Ft (force-time) is sometimes called impulse.'' Now this Ft, he asserts, equals v (velocity) multiplied by W (weight) and divided by g (acceleration), and this, in turn, equals mv (mass multipled by velocity), for mass is proportional to weight divided by acceleration. Having found that Ft, or impulse, equals mv, then, since mv equals momentum, impulse must equal momentum. Professor Kent says that momentum ''in many books erroneously defined as quantity of motion in a body, is the product of the mass by the velocity of any instant.'' Momentum is ''equivalent to the number of pounds of force that will stop a moving body in one second, or the number of pounds of force which acting during one second will give it the given velocity.''

In defining momentum in terms of a force which acts through the period of one second only, Professor Kent implies that a single second of time can adequately stand here for unit time. Yet he does not say what he means by unit time. Nor does he tell us what happens (theoretically, at least) in one second that does not happen in two seconds, or in one-half a second. If force is measured in terms of the weight of matter, how much weight-force will be expressed in one second? Is this the unit of weight-force? This cannot be, for surely less weight-force is expressed in one-half second than in one second. One second cannot be the "absolute" unit of time, the unit for all cases, the unit of number in the formulation of mechanics, for time may be divided into much smaller intervals without reaching a duration where in a proportionate amount of weight-force fails to appear. The physicists seem little concerned about the actual duration of that smallest unit of time in which force may act to cancel the momentum of the body. One time seems to suit for the unit as well as another so long, as all the momentum is actually cancelled by the force within that duration, so long as no other outside influence enters meanwhile which might interfere appreciably with this accomplishment, and especially, for formulation purposes, so long as the time-interval may be represented satisfactorily by the numeral "one" (1).

We have observed that the momentum of a moving body is defined quantitatively as equal to a certain amount of force; and that force is required to cancel momentum. Does this not signify that momentum is a type of force? Yet, if momentum represents force-delivery, might it not stand also for a certain amount of energy-delivery? Or does the word "energy" refer to something basically different from this force which is used to overcome momentum?

Force acting through unit-time annuls momentum: What, then, will cancel energy? And is the force of a body annulled at the same time that its motion (its momentum) is annulled? If force may be consumed in reducing and cancelling momentum, is energy consumed likewise during this tiny interval when momentum is being cancelled? And if the force of weight repeatedly cancels momentum, second after second, can this weight-force also express energy during this same elapsed time? Or, does the use of weight-force through a series of unit intervals, substract proportionately from its ability to express kinetic energy during the same amount of elapsed time? If the entire second is used by a weight-force in cancelling momentum, and then the next second, and so on, why does it not follow that the energy of weights, during any amount of time, may be diverted and consumed in the cancellation of momentum? If such be the case, however, what is the difference between momentum and kinetic energy?

We have received a definite answer from science to at least one of these questions. The physicists tell us that energy cannot be consumed by use—that it may only be transferred. What, then, is energy? Is it really as represented—namely, a character possessing a separate reality; or is it a mere derivative by special definition of something still more fundamental, something, for example, like force—that which matter has when possessed with relative motion? Even relative motion, however, the most fundamental attribute which matter can display, can be consumed by an opposed force. And momentum, so the physicists admit, is destructible without compensation. How, then, might energy be a particular manifestation or distinct type of force and yet be indestructible?

Energy seems to be allied with motion. Indeed, it is so dependent upon mass and velocity that we do not see how momentum—which is also allied with mass and velocity—can fail to be related to energy by some logical connection; and yet it would seem that if this connection were traced it would be equivalent to disproving the doctrine of Conservation. Let us proceed, however, without preconceptions or rigid beliefs. Since we do not know what energy is, how can we dogmatically uphold Conservation? Let us first try to get clear ideas; and then, if we feel confident that we have reached a correct general understanding of principles, we may try to establish relationships. We must strive to attain precise definitions, exact units, for important issues are involved.

In the text-books, energy is defined as "the capacity for doing work"; and work is defined as "the overcoming of resistance through a certain distance." Professor L. B. Spinney tells us that in the mechanical usages "motion is an essential part of work." For example, "the pillars which support a roof are exerting large force actions upon the roof, but they are doing no work since there is no motion." This seems to be a very arbitrary definition. As thus limited we would say that energy is to be regarded as a special type of force-application—of that force-application, indeed, where there is a *visible* effect in motion, and a *measurable* amount of work finally done. The distinctive amount of unbalanced motion required for an appearance of energy is not stated, nor is it given in any of the text-books.

Let us suppose that motion is present in the case of pillars supporting the roof; that there is a slight but unperceived vibration back and forth between the forces downward of gravity on the roof and the forces upward of the structure of the pillars? What, then? Is work being done? Is work being expressed in these separate pulsations of temporarily unbalanced motions? Or, what about the case referred to in the Introduction where the ball visibly rises and falls on top of the spray of a fountain, and where motion is unbalanced perceptibly, and for a calculable interval? Is work being done stage after stage when the ball is first raised and then depressed through distance? Is energy present here? And, if work *is* being done, if energy *is* used in creating these reversed motions, what at last becomes of it?

These cases—the roof supported by the pillars, the ball on the fountain, and the weight mashing the air-balloon, and supported in balance by the vibrating air-molecules—all seem to represent one type of phenomenon. Bodies move and are moved, the motion of matter is created first in one direction and then in another, work is being done, energy is being expressed; but, at the conclusion of the event, there remains no measure of unbalanced motion, no perceptible work done. Have we a right to say, however, that no energy is expressed merely because we cannot see a final accomplishment? Do we say this merely because we believe in the Conservation of energy.

Or, have we a right to escape the issue by asserting that the energy referred to in the Conservation doctrine is a special branch of force-manifestation—namely, that force which does end with work accomplished through *appreciable* distance and for a certain distinguishable time—distinguishable, that is, to our gross type of sense-perceptions? As though basic reality could depend upon the nature of the human faculties!

To this ingenious limitation of the doctrine (one which excludes the finally balanced oscillations of the ball on the fountain, and the minute oscillations of the roof on the pillars, and which attempts to retain the idea of Conservation in the face of its apparent failure), we may reply that if one waits long enough, no work of any sort will finally remain uncompensated. Every movement will sooner or later be retraced, and, on this theory, finally, no energy is expressed. All movements are parts of cycles and all cycles return (approximately) to the state of the beginning. Do we wish to hold to Conservation on such terms—by making use of such an argument? Yet, according to its definition, energy certainly appears to be a special, time-bound, form of force in general. Energy is that force-application which at the end of some duration more than the minimum, displays uncompensated work done. That is to say, energy, as conceived in physics, does not appear to include the unit of force-delivery, the unit of its own expression.

It would seem that after a certain time all force-expressions which we call energy are converted by reversals of movements into a condition in which no unbalanced motions remain, and wherein no final work is done. If that which we call energy is the force-manifestation of only one part of the cycle, why trouble to distinguish it from momentum? And why try to prove that it is perfectly conserved during that time when it does exist in unbalanced fashion? This special form of force-manifestation is not particularly important, because if one refers to that which happens instant by instant (the unit event) the word "energy" has no separate meaning, and if one will but wait, its temporary significance and reality will disappear.

Energy, it would seem, is something which for some particular duration is definable in terms of time and space. It might never be; it might never have been, and it will never continue to be. And a world could exist with mass-movements, with force-expressions, with actions and reactions, and yet display nothing which the physicist would define as work finally done or energy finally manifested through conquered distances against resistances.

Since the physicist defines and measures energy in his own arbitrary terms, if one gives the name of "energy" to this type of force-manifestation (a force-manifestation which by its very definition is unbalanced) it is of course easy to derive a special principle involving at least the temporary Conservation of this sort of energy. Yet this Conservation principle will signify merely that the type of energy which is measured by work unbalanced through distance, is, indeed, forever equal to the work which is unbalanced through distance. And one may add that the perfect equality of this equation is eternal. But this is no proof that the quantity of unbalanced energy of the universe is constant.

This, perhaps, is the proper way of looking at the phenomenon of energy as defined in the text-books. We are not told, however, what energy is, and why it has a formula different from that of momentum. And there are other perplexing questions. The energy of the physicists' definition may be expressed only through distance. Through what minimum distance? If energy may be expressed only through a distance greater than unity, what is unit distance? Unless we define unit distance how can we tell in any certain case whether or not energy is being expressed? And if it is admitted that energy cannot be expressed in less than some certain minimum distance, why is this so? Or, if we should agree that energy may not be expressed in unit distance, we may then ask whether it can be expressed in unit time. Again we question: What is unit time? And what is this force-character which by being expressed under conditions of distance and duration less than those required for energy-expression may somehow be summarized unit upon unit until it reaches the dignity of an energy-expression? Is not the energy-whole composed of its parts? Is not the nature of this whole the same as the nature of its parts? How can it be otherwise? And yet how can it be so if we are to believe what the classical physicists believe?

Still other questions must be asked. When a body moving freely in space is resisted so that it gradually surrenders its motion, is work done in stopping it? Yes, for this is the kind of work that energy does. And yet if it is really energy that cancels the momentum of such a moving body, why isn't energy in some respects the same as momentum? Doesn't force acting through time also cancel a motion, or momentum? Suppose the motion of a mass is stopped almost instantaneously, as when a bullet strikes armor-plate. Is it energy that is consumed in stopping it? Or does the answer depend upon the distance the body moves while being brought to rest? Evidently we do not clearly understand this mysterious something that we call "energy."

Momentum is force-time (Ft), and energy is force-distance (Fs). When time (t) is reduced to numerical unity (1), however, momentum becomes (F) (1), or F (or pure force). Why, then, if distance (s) is reduced to numerical unity (1), shouldn't energy also become (F) (1), or F? If the real units of time and distance are reached simultaneously (and they should if the number-system has been properly applied), both energy and momentum would equal F, and equal each other. Why, then, shouldn't there be some constant and simple numerical ratio of energy to momentum as the distance through which work is done is increased above unity (1)? If some simple law connected energy and momentum for different distances the principles would appear to be separated in being only by quantity, not quality. Certainly, energy and momentum seem to be composed of the same force-stuff during the mysterious unit situation—during that unity which has not yet been defined explicitly. Momentum and energy might be composed of the same force-essence, even though they subscribe to different formulas during certain situations. This, however, would not be the conventional view, because momentum alone is supposed to be destructible. If the Conservation theory is true of energy alone, then surely there can be no conceivable relation between momentum and energy.

From still another viewpoint one might question how the force which participates in momentum might be different from the force expressed in terms of kinetic energy; for is not the formula for energy derived directly from the formula for momentum? Momentum (Ft) equals mv, so F equals mv divided by t. Multiplying both sides by s we have the equation; Fs equals mvs divided by t. Now a distance (s) traversed by a uniformly accelerating body which starts from rest is conventionally stated numerically in terms of the product of its average velocity (V) per second by the number of seconds (t) that it moves. That is, s equals Vt. Average velocity in this case equals one-half the final velocity, and if we assume that the 'v' given in the momentum formula is the same as this final velocity, then average velocity (V) equals ½v, and s equals ½vt. Substituting this last value for the s in the equation Fs equals mvs, we learn that Fs (kinetic energy) equals (½vt) (mv) divided by t. Cancelling out, we derive the conventional formula that kinetic energy equals ½ mv^2.

Now in this case, the force (F) of the momentum formula is certainly the same force (F) which appears in the kinetic energy formula. The propriety of substituting the "v" of an accelerated body for the "v" of a formula involving momentum and unaccelerated velocity only, might, however, be questioned. We might question also some of the other substitutions (knowing what we do of the significance of the numerical units), but the force (F) which creates motion through the use of momentum in unit time is undoubtedly the same as the force (F) which, when expressed repeatedly through distance, increases velocity moment after moment. If any kind of force (F) may be destroyed without compensation, therefore (either that which is known in the momentum-formula, or that which acts as energy), the Conservation doctrine must be held invalid.

Basing my opinion entirely upon theory, I concluded in earlier pages that the Conservation theory was untenable. A clear understanding of the nature of energy, and of its relation to momentum, may support this conclusion. So far we have not obtained this understanding. We do not know exactly what the terms mean. We have not identified the limiting conditions for each; we have not defined the minimums of the distances or times wherein momentum ceases to function, and where the formula of energy begins to be useful; we have not adopted exact units; we have not perceived the reason for the difference in formula. Indeed, we have been inclined to accept the numerical rules simply because they were practical. We must now know *why* these rules are practical. We must know what they stand for in universal terms if we are ever to obtain a philosophical insight into the realities. Before attempting this explanation, however, it may be well to continue with our text-book definitions to see whether we can find here something that will help us to understand.

Sir William Thomson said that C. F. Gauss made a contribution of great value to the science of dynamics by his definition of "unit force as that force which, acting on a unit of mass for a unit of time, generates a velocity equal to the unit of velocity. It leaves the units of mass, length, and time to be assumed arbitrarily." Unit force is given as the equivalent of unit momentum, for velocity is derived exactly in proportion to its quantity. Sir William remarked pertinently of the principle set forth by Gauss, that there is an "interlocking of two definitions:—the unit of force defined in terms of the units of mass, length, and time; the unit of mass defined in terms of the unit of force and the unit of length." He then said:

> It might seem as if we were proceeding in a vicious circle; but the circle is not vicious,—the two definitions are logically and clearly interdependent. We have, as it were, two unknown quantities and two equations; and the elimination of one of the unknown quantities from the two equations gives us the other explicity. The two are mixed up in a somewhat embarrassing way in the primitive definitions, but when we disentangle them we arrive at the simple result."[1]

It would seem to me that there are four unknown quantities in these two equations instead of two; and that the definition is not a definition at all, but merely a statement made in an attempt to describe an experience in some terms. Nor is it at all certain that the relations of reality are such that the terms can properly be transposed from one equation to the other, and still accurately apply to every situation. Indeed, this seems hardly possible.

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[1] Sir William Thomson: *Electrical Units of Measurements.*

Professor Spinney and Professor Prescott use definitions similar to those of Professor Kent. Professor Spinney defines momentum as ''the product of the mass of a body by its velocity.'' Momentum is defined in terms of that which measures it. But this lacks finality. What is a house? If we say that a house is so many thousand pounds of brick, wood, and steel, have we fully defined a house?

The *Encyclopædia Britannica,* under the heading *Units, Physical,* says ''Momentum is defined as the product of mass into velocity: unit momentum is therefore the momentum of unit mass into velocity.'' ''Force,'' it says, ''being measured by the change of momentum in unit time, is expressed in terms of the same units in which unit momentum is defined.''

The difference between the measures of a discontinuous force like momentum, which can be consumed once only, is calculated in terms of the increase in simply velocity in a freely moving mass; whereas the work done by a continuous force like weight, in overcoming resistance to a mass as it moved through distance, is measured as a direct ratio of the product of the mass and one-half the maintained velocity squared. It is supposed, also, that the energy required to stop a body which is moving through a continuing resistance is equal to the same quantity. The relation between the potential force of momentum as stored up in a moving body and the energy required to bring it to rest is not explained. Nor does the *Encyclopædia Britannica* give us an inkling of the true significance of the numerical units.

Professor Frank L. Griffin, in his *Introduction to Mathematical Analysis,* says that ''A force acting upon an object imparts 'momentum' to it. The amount of momentum equals the average force, multiplied by the length of time.'' This definition corresponds with Kent's, except that here the force is taken in its aspect of creating, instead of cancelling, momentum. If the force of a weight is in question, the force can continue to add velocity to an object without being itself consumed, for this force continues undiminished moment after moment; but if the force is that of the blow of a body moving horizontally, as if sliding on ice, then a limited amount of force can be delivered by it, and, after a certain time, the acceleration which it can cause will cease. Within a very short time in the usual collision the relative motion of the striking body is transferred to the struck object. If an object sliding on ice strikes another at rest, the struck object will move on with the striker; but if the striker is a bullet colliding with impenetrable armor-plate, the bullet will lose all of its force and motion, and will soon be at rest. The bullet has only one "charge" of motion to surrender. When the bullet has come to rest, it has lost all of its momentum, as well as all the kinetic energy which it previously possessed. This is the condition of the ballistic-pendulum, a phenomenon which will be discussed on a later page. Here we merely say that no clear distinction is drawn in physics between deliverable momentum, force, and kinetic energy in cases where the motion is delivered within a comparatively short time. A weight continues to express force through extended time even after it has been brought to rest.

Professor Prescott, in his book entitled *Mechanics of Particles and Rigid Bodies,* speaks of the moment of the momentum of a particle, which is nothing more nor less than the moment of the vector, or namely, "the momentum of the particle." (p. 494) He says also that:

> The momentum of the particle of mass traveling at a velocity v is a vector of magnitude mv with a definite position in space, since it passes through the position of the particle itself. The moment of this momentum about any point is the product of the momentum and the perpendicular on the line of the vector, that is, the line of motion. It corresponds exactly to the moment of a force, and the properties of moments of forces can be extended to moments of momenta. (p. 343)

The moment of a force would be described more clearly by Professor Prescott if he had told us exactly what force was. The moment of a force, he says, is "the product of the force and the perpendicular distance of the point from the line of the force." (p. 20) Without explanation, we are advised also that we may multiply a force by a distance and obtain a significant product. It would seem about as reasonable to expect a sensible result from the multiplication of tallness by goodness. What is this "force" which can thus be multiplied by distance so significantly? Says Professor Prescott:

> That which changes the motion of a body from uniform motion in a straight line, or which sets a body in motion, is called a force. There are forces which do not seem to be embraced in the preceding definition. The physical action which we may call a force may exist, but no motion may ensue, because its effect is exactly counterbalanced by other forces. We may, however, consider, even in this case, that each force is actually producing its own motion independently of all the other forces, providing that the displacements produced by the several forces are added by the rule shortly to be given. (p. 2)

Let us consider this case where force exists but where there is no detectible motion because the action of the force is annulled by an opposed force-action. According to Professor Prescott, we may consider that each force is "producing its own motion"; but it would seem that we are entitled to this conclusion provided only that we summarize the displacements according to some certain rule. This case of forces acting without permanent movements is similar to the illustration given by Professor Spinney of the force-actions between the pillars and the roof of a building; except that we now learn from Professor Prescott that, even in such a case, each force (the weight downward and the shove of the pillar upward) may, perhaps, be "producing its own motion." Certainly, the principle would be unchanged if each force were producing its own motion provided that the distance was very tiny so that the oscillation one way was quickly counterbalanced by the opposed motion.

Suppose a cloth is suspended between two fans, each of which is discharging air against it. It might hang there in almost perfect balance without perceptible motion, although the air-molecules are striking it intermittently from both sides. For this reason the sheet will oscillate slightly, even though the movement is indetectible. Each air-molecule, as it strikes, is moving the sheet. Probably it is the same way with the roof resting on the pillars—just as it is with the ball supported by the spray of the fountain, or the microphone disc vibrating in the electric field. In the case of the ball on the spray there is an oscillating motion which must be considered, for it is actual, unquestionable. It is utterly real, regardless of how the displacements are computed. Here a force-action creates motion through distance—but through a very short distance. The question then arises: Is this force-action an energy-manifestation, or a part of an energy-effect, or is it not? The opposed force-actions seem to cancel each other; and there is no evidence of compensating heat-radiations.

Especially is it true that no heat-radiations emanate from the force-actions between roof and pillars. Yet, so far as we can judge, all these cases are identical in principle. Certainly, if the action of gravity is conceived as being discontinuously granular—a concept which would not change the formulas radically, and which would help us much philosophically—then there would be the same type of oscillation in respect of the roof and supporting pillars as obtains in the case of the sheet suspended between the air fans. If, however, there is motion in every successful resistance to weight-force (even though through such a tiny distance and for such a minute interval as to be indetectible), one would think that the usual sort of kinetic energy was being displayed. And yet if one kinetic energy does balance another in this fashion through a slight period of oscillation, and does so year after year without energy-radiations or shift of parts which can account for the use of kinetic energy, it follows that the Conservation doctrine is radically unsound.

Rather than surrender Conservation the physicists assume that there is not sufficient motion in these cases to exemplify that which they define as even a part of an energy-expression. Pure force is being expressed, perhaps, but certainly not energy. In the case of the sheet, where the separate impulses of the air-molecules are detectible, the force-expressions are regarded as a series of typical momenta—and the same would be deemed true of the gravitational weight of the roof if it could be proved granular. These opposed momenta, it is said, may cancel each other, and it is quite unnecessary to explain where these forces go. It is believed that momentum is so different from energy in its very nature that a plus momentum acting against an equal minus momentum develops a zero. Unlike energy, momenta may vanish at any time. For this reason momenta are not realities. They are nothing more than ways of looking at states of affairs when nothing really happens that is worth noting.

This is what is taught in classic physics, but, at other times and in other places, these momenta seem to be utterly real, and capable of doing the same sort of thing that energy does—namely, the imparting of the motion, the doing of real work.

That which would be a real energy-demonstration if it were allowed to proceed far enough through distance (the case of the roof oscillating slightly in reference to the pillars), and if it were not compensated quickly by an opposed action, becomes something less real when these compensations reduce the final motion through time to zero. Billions of miles may be travelled each year by a book resting on a table in its fallings and risings, but according to physicists no final force has been expressed through distance, nothing real in the way of energy has been manifested, and there has been no destruction of anything of importance. Momentum can appear or disappear, or can act or be acted against, and motion of matter can exist in one direction and then in another, but so long as there is no final movement through distance which stands there as work accomplished, there is nothing to be concerned about.

It is easy to see how the physicists have limited the reality of energy by their mystifying definition—a definition which permits them to believe in Conservation in the very face of the destruction of real motion of mass. The man on the street has the idea that science teaches that every kind of force is indestructible. He thinks it makes no difference whether the motion caused by the force-action is too tiny to be detected, or whether it is compensated fully within the tiniest of time-intervals. This, however, is not what the scientist usually means. His energy has a specific and well-defined reality. He is talking about a certain kind of force-action—not free unaccelerated motion in space, not compensated motion where one force meets another head-on, and through a short time balances it, but uncompensated motion through *appreciable* distance where the force-action either accomplishes acceleration in a mass or maintains motion against resistance. As already stated, the physicist does not identify the minimum limits of distance or time which must be passed through before the momentum becomes a real energy.

The physicists first developed formulas to suit their practices; then they made theories to suit their formulas; and finally definitions were arranged to enclose their theories. Particularly was the definition of energy restricted so as not to contradict the theory of the Conservation of energy. Yet a definition thus limited, or a theory thus reduced in bounds, has no great significance. If one defined a man as a certain type of animal six feet tall, the doctrine that all men are six feet high would be completely sound, but unimportant. Energy, as it is defined, does not stand for all force-action more than ''man'' in the preceding example stands for every adult male of the human race, and yet—and this is my important point—the Conservation doctrine is supposed to stand for some valuable and all-inclusive truth. Let us further consider this matter of kinetic energy to be sure that we are correct in stating that it is a limited type of force-action, representative merely of work done, and that the Conservation of it means nothing more than the Conservation of that which by its own definition is conserved.

A scale-beam stays in balance on the principle of the force-actions of momenta—not on the principle of kinetic energies. A ten-pound weight two feet from the fulcrum of a lever will balance a five-pound weight four feet from the fulcrum on the opposite side. Even when the weights drop from high in the air and are charged with a tremendous velocity and tremendous kinetic energy of motion, they still deliver momenta when they strike, and not kinetic energies. This is proved by the fact that if equal falling weights with different velocities strike a scale-beam at the distance of two and four feet respectively on opposite sides of the fulcrum point, the scale-beam will be balanced (at the instant of impact only) when that weight which strikes two feet from the fulcrum point moves with twice the velocity of the other. This balance is obtained numerically only if the striking forces are computed as momenta. If the formula of kinetic energy ($\frac{1}{2}mv^2$) should be used in respect of the delivered impacts of these two falling weights, the numerical result will be out of balance—and will not fit in with the facts. If the weight should *remain* on the scale-beam, however, the balance will be destroyed, for the gravitational forces of the two equal weights when at rest are equal. And the beam will be unbalanced unless the equal weights are placed at equal distances from the fulcrum.

This experiment proves that the force derivable very quickly from falling bodies is measurable as a momentum, and not as kinetic energy; but the physicist escapes this difficulty by asserting that the falling weight does not here do work through appreciable distance, and, therefore, according to definition, the forces expended against the beam at the moment of contact are nothing but momenta, and the kinetic energy which each falling weight possesses is consumed in heat-radiations and shifts of parts, and in similar ways which we do not usually detect. It is believed that this statement provides a satisfactory escape through the horns of the dilemma.

I shall now illustrate the phenomenon of the ''ballistic pendulum'', for it adds to the proof that the distinction between kinetic energy and momentum is artificial; and that kinetic energy as defined is merely a special case of force-manifestation—a case so special, indeed, that it requires a different formula. Both the illustration and the description of the ballistic pendulum are taken from pages 108–9 of Professor Spinney's book.

''Let M, Figure 67, represent a large block of wood suspended pendulum-wise as indicated. Let it be imagined that a rifle bullet is fired into this pendulum. It is required to find the velocity of the bullet v at the moment it comes in contact with the pendulum. Call the mass of the pendulum M and the mass of the bullet m. Evidently the pendulum and the bullet swing as one body after the impact, the mass being M plus m. If m is very small in comparison with M, it may be neglected after impacting with M. Therefore, from the principle above enunciated, we have reached the formula MV equals mv."

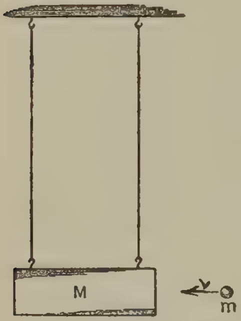

Fig. 67

As Professor Spinney points out, the velocity of the bullet after impact is so small in comparison to its original velocity v that it may be neglected.

The velocity (V) of the pendulum at the instant that the bullet has delivered approximately all of its force is determined by measuring the height of its swing. A certain height signifies that it started off after the bullet struck with a certain definite velocity. The velocity of the bullet (v) may be determined by calculating the product of the velocity of the pendulum (V) by its mass (M), and by dividing this product (MV) by the mass of the bullet m. The velocity of the bullet (v) is obtained, therefore, from the equation which states that v equals MV divided by m. This equation signifies, in turn, that the momentum of the bullet before striking equals the momentum of the pendulum after being struck—namely, that mv equals MV. The reader will note that the formula of momentum, and not of kinetic energy, is used here. Nevertheless, the bullet has lost practically all of its kinetic energy, and this energy must have been consumed chiefly in doing the work of moving the pendulum.

What has become of this energy of the bullet—the force of its motion—if it has not gone into the motion and energy of the pendulum, and if it is something different from its momentum? And why should we use the formula of momentum for the delivery of this force to the pendulum? Why does the formula for kinetic energy give absurd results here, and fail to correspond with reality? The physicists have not told us, because they have failed to make a clear distinction between the realities of different cases. The physicist merely assumes that a reduction of kinetic energy is to be accounted for in shifts of parts and in heat-radiations—a possibility which we discuss at length in another chapter.

Suppose the bullet weighs one pound and is moving at a velocity of 300 feet a second. How much velocity-effect will a vertical 12-pound pendulum acquire from its blow? At what speed will the pendulum be moving when it swings back through the vertical point? According to physics, this velocity will equal approximately 300 × 1 divided by 12, or 25 feet a second. This result is obtained from the formulas of momenta as just quoted. This is simple enough: but other questions are to be asked: First, what kinetic energy does the pendulum express on its return to the vertical point with a velocity of 25 feet a second? What kinetic energy would it express by its continued horizontal motion at this speed if the supporting string were cut at this point, and if it were allowed to slide away on a frictionless surface until it delivered its energy of motion to some other body? According to formula, its kinetic energy of motion ($\frac{1}{2}mv^2$) will be $\frac{1}{2} \times 10 \times 25^2$ foot-pounds. But the pendulum has received and has returned practically all of the kinetic energy of the bullet. If the original contour and structure of the pendulum has been restored by the time it returns to the vertical position, no appreciable kinetic energy is to be accounted for in shifts of parts or in heat-phenomena. As the pendulum obtains its energy of motion only from the bullet, its acquired energy should equal approximately that which the bullet loses. The question now becomes this: Did the bullet lose the amount of energy that the pendulum acquired from it? The original kinetic energy of the bullet equalled, not 3,125 foot-pounds, but $\frac{1}{2} \times 1 \times 300^2$ foot-pounds, or 45,000 foot-pounds. Now, obviously enough, the bullet cannot lose 45,000 foot-pounds of kinetic energy to the pendulum if the pendulum receives only 3,125 foot-pounds of kinetic energy from the bullet. There in some error here. Where is it?

The difficulty lies in the supposition that kinetic energy has any part to play in this delivery of motion to the pendulum by the bullet. The formula of kinetic energy does not apply to this particular case of doing the work. An application of the principle already discussed makes this clear. When the pendulum has swung back to the point where it was struck by the bullet, gravitational resistance and retardations (and all environmental conditions) have been fully compensated and returned to it in accelerations, and there remains in it only the motion and *force* of motion which were delivered by the bullet. The force of the bullet, moreover, was delivered as if instantaneously. At least, it may be so regarded, for on its return to the vertical the pendulum has approximately the velocity that it would have received from the blow of the bullet if both bullet and pendulum were solid, and if the force had been delivered instantaneously and in empty space. No velocity-retardation remains of that which was accumulated out of the environment as the pendulum moved up against gravity, for the gravitational resistances have been compensated and returned at the bottom of the downward swing. This problem, therefore, does not relate to the force-delivery required to add velocity to a body while it is overcoming resistance through distance. On this account, the formula of momentum applies. Here momentum creates kinetic-energy, it would seem.

Force is required to shove a body against an elastic spring, too, after the object has returned to the starting-point, the resistances compressing the spring, the accumulating contacts of mashing the spring through space and time are required by its expansion, and the events of the compression are almost fully compensated and need no longer enter into the calculation. The action of gravity is similar to that of a perfectly elastic spring, and, for this reason, the ballistic pendulum represents a compensated cycle of motion to and from a point in space. By the return to the starting-point, the effects of the motion in the resisting environment are fully restored as if by a perfectly elastic resisting medium. The velocity of the ballistic pendulum at the perpendicular point, therefore, represents the velocity that the pendulum would have taken if the collision had occurred in an environment which contained no gravitational forces to act as a resisting medium. The amount of force which is lost by the bullet and received by the pendulum is to be measured, therefore, not by making use of the formula for kinetic energy, but by using a formula which is applicable to force that is completely delivered in unit time and distance.

We have now obtained about all the information on this subject available in conventional physics. Before closing this chapter—that is, before developing the principles and formulas of momentum and kinetic energy from other premises—an additional word should be said about elastic impact.

The phenomenon of elasticity is discussed at some length in other pages. I shall merely repeat here that no body is ''elastic'' of itself, but that every mass receives its ability to repel other bodies, not from some interior and hidden source of power of repulsion which can be used moment after moment without diminution, but from some source of power which is acting upon the body from the environment. A taut sail is ''elastic'' against blows delivered on its bulging side because it is being struck on the opposite side by a flow of air-molecules. Let this flow cease and the elastic sail will become a limp rag. The air-balloon which supports the force of a weight resting upon it hour after hour receives its ''elastic'' energy from outside itself. An inelastic ball rebounds from an elastic floor because the floor, when compressed, delivers to the ball some force which it receives (when compressed) in unbalanced fashion from an exterior source of power. When an inelastic body (composed of solid inelastic unit-bits, as all material structures are) strikes a motionless body in free space, it will be impossible for the striking body to rebound from the one which is struck unless the struck body contains parts *which are at that time moving in opposition to the striking body.* If the struck body is continuously able to repel striking bodies, it also must receive this energy of motion of its parts from an exterior source of power. Otherwise force would be created by and out of matter—something which no one claims.

Professor Spinney thus comments on this phenomenon:

> In elastic impact work is done in distorting the impacting bodies and energy is stored momentarily as potential energy. If the bodies are perfectly elastic, they

> will recover completely from the distortion and will therefore return all of the energy which was expended in distorting them. (p. 108).

The question of the source of the power of recovery seems to be dismissed here. Unless the elastic structure which is struck by the inelastic body is backed up by another elastic structure, it will move ahead when it is struck—just as one rock sliding on ice drives on the one ahead. Again, unless the elastic structure which backs up the struck body is itself backed up by another elastic structure beyond, it, too, will move on when it receives the force of the striker through the body first struck. Thus, in order to obtain a rebound we may postulate that there is something of the nature of an immovable wall somewhere in the background which will not yield to a blow. This postulate, however, is unreal when taken of physical substance. There is no immovable matter. Our postulate must be limited, therefore, to the assumption that there is somewhere a source of motion in a direction opposite to that of the striker, (either affecting the striker or the struck body, or both) a power which is sufficient to annul and even to reverse the motion of the striker, and which acts on the structure of the elastic body because of the fact that this structure has been altered abnormally by the force applied against it from one side. Certainly, we cannot agree with the intimation that the elastic body of itself supplies the power of returning ''all of the energy which was expended in distorting it.''

Suppose two ''elastic'' bodies like air-balloons collide when moving in opposite directions at equal speeds. The two balloons will rebound from each other and will be restored to their original shapes; but this power of rebound and of restoration is not derived (as intimated in physics) from a quality possessed within the balloons. The force of reaction always comes from a cause of motion acting outside of and against the parts of the body which we designate as being ''elastic''. In the case of the balloons, it is this exterior power which gives the repeating oscillatory movements of the separate air-molecules. It is this power which indirectly holds the cover of the balloons taut and gives them this property which we speak of as "elasticity". A structure is elastic in the ratio that its structure *when distorted will receive more of this unperceived exterior force from one direction than another.* It is this principle which causes the two colliding balloons to react from each other.

With this ground clear we should be ready to compose our definitions and construct our formulas. First we must attain a concept of basic force; and then we can develop the mechanical and mathematical terms which will express its application to matter in unit form. Afterwards, we shall make modifications in this unit formula to make it applicable to every known environment. We shall find, then, that the formula of kinetic energy may be derived easily as a special form of the mechanical formula of momentum which measures pure (or unit) force.

And we must remember, too, that only numbers can be multiplied. The symbol Ft is mainingless until it is thrown into numerically distinct quantities (or into multiples of discrete unit-expressions of force and time that have fundamental reality in mechanics), and numbers cannot be properly applied to force and time, therefore, until the true units of force and time (the numerical "ones" (1's) of force and time) have been revealed to our minds. Only when this has been done can the significance of the product of force and time be understood and its formulation philosophically justified. And when it is done, the principles underlying mechanics will for the first time be clearly revealed, and the formulas themselves will take on a new significance and will be valued only for what they are—namely inaccurate generalizations of practicability, relating with fair accuracy (only) to the average condition of certain orderly composite (spread through a space and time that really take no part in mechanical events themselves) happenings—those happenings which make appreciable records on our organs of sensation.

CHAPTER XXII

DEFINING THE KINETIC ENERGY FORMULA IN TERMS OF MOMENTUM

> Theory is the greatest tool that science has. It even exceeds experimentation in value.
>
> M. Luckiesh.

In this chapter I shall endeavour to define momentum and kinetic energy clearly and to account for the difference in their formulas. First, however, I shall define some of the characters which appear in mechanics. The definition of matter was given in the previous chapter. With regard to "force", as already said, the ability to make matter move is the distinguishing attribute of mind when observed in its relations with the physical. Primarily, then, the definition of force, or motion, must be spiritually grounded.

The theory that motion has a mental origin, however, does not in any way concern practical mechanics, for the physicist first becomes interested in a particle of matter through its delivery or acceptance of motion. What started the motion-sequence in an earlier history does not concern him. In physics, force is never measured in terms of mental units, but is always stated in terms of the motion of a mass with inertia. It is this inertia of matter, indeed, which absorbs and limits the ability of the mental power to create mechanical motion. And so the force-measure of mechanics must be reckoned in terms of the velocity of the smallest bit of matter, and in proportion to some multiple of its inertia. What, however, is the unit of velocity—that which measures motion to us?

Velocity is always given in terms of time and distance. We shall begin, then, by saying that unit-velocity is the speed per second which is given the smallest particle of matter at bounds towards the centre of mass by the mental Power which restrains the finite universe. It is that velocity with which a single particle is repelled by external Power from the limits of space towards the centre of the energy-pool of the universe. Our unit-velocity perhaps equals the speed with which light-energy reaches us from the bounds of the universe. This definition might be acceptable to those who have our concept of the universal pressure-pool, but only provided that the particles conveying the energy of light are corpuscles which are separated from other corpuscles by unit-distance. What, however, is unit-distance?

The universe, if it is finite in volume, and if it has finite mass, contains a definite number of particles. Unit-distance, then, when taken in one sense, is the average distance between these particles. This is a specific space-quantity. It may not be calculable, but it is at least imaginable; and it may stand for us as the unit of distance where force-delivery is involved. As we observe elsewhere, however, the unit of physical extension, the unit of physical measurement in statistics, is the diameter of the unit bit of matter.

It is suggested that the velocity of light-translation should be taken as our standard measure of motion. Certainly, it seems to be the maximum velocity of energy-transmission between distant volumes in our world, and, therefore, should represent the average and normal translation of force (in one direction) by the smallest free units of matter. Furthermore, it appears to be practically constant—at least in the regions near us. This average ''charge'' of motion, we believe, permeates the volumes of the universe, restrains the universe, and maintains the average force-expression within it near the earth. Unit-mass, moving with this velocity, delivers the head-on unit-blow, and thus maintains the average energy of our part of the pool. It is the velocity (not the speed of the particles themselves, but of their straight-line energy-translation by contacts) which decreases within the bounds of the whole as particle comes into contact with particle. This velocity averages less as the average distance between particles of a composite body is less. The velocities of the average movement of energy is less within a dense than within a diffuse volume. Velocity (in so far as it refers to the straight-line transmission of radiant energy) may not be uniform throughout the inter-world spaces, however, for the average speed of radiant energy of the oscillating corpuscles may be greater near the universal bounds; but at any one place a certain average speed of the energy-movements outside the atoms of the elements will obtain, and this velocity should be taken as the working unit for this environment. In a huge balloon the molecular motion is probably less swift as the centre is approached, but in any one volume within the whole the molecules doubtless transmit energy in one direction at uniform speed.

Now the average distance traversed by one unit bit of matter while making a head-on contact with another, is not the same as the average distance between particles, for particles will move many times this distance without receiving the full effect of one head-on collision. In dynamics, therefore, unit-distance is the average space through which a particle moves before it receives from its various contacts (deflecting and otherwise) a resistance equivalent to a head-on collision with another particle. Unit-distance is, therefore, a constant at one particular spot, and, except as Evolution alters it, is a uniform multiple both of the average distance between unit-particles at that spot, and of the extension of the unit bit of matter.

The actual figures for unit-velocity-and-distance may be one thing or another; their values may not be calculable; but the formulations of delivered force may be derived without knowing them exactly. The real measure of the units need not concern us here. Reason tells us, however, that an absence of ''absolute'' velocity (''absolute'' velocity here being measured in terms of straight-line motion relative to the centre of mass) is unknown except for short intervals. To speak of a body at rest is usually nothing more than a way of locating some other body which is moving in reference to it. To be really at rest a body would not be moving in reference to the universal centre; and there are no such bodies. We have now described our units of distance, of velocity, and of force. The unit of mechanical force is the ability of a unit-particle, when "charged" with unit-velocity, to make another motionless particle move when striking head-on. We may experience less than this unit of force, for a particle may move (for a while at least) with less than unit-velocity. It may also give a glancing blow. The unit of force, therefore, is not necessarily the minimum force-expression. When averaged through any appreciable duration, however, unit force is both the minimum and maximum energy which is being expressed against every surface during a unit of the time. It is the *average* perpendicular component of force-expression which during unit-time is everywhere manifested by the blows of unit bits of matter against a unit area.

Experience alone has taught us that the quantity of force in a body is proportional to its velocity. A striking corpuscle in head-on contact makes another relatively motionless one move at half its original velocity. This is the maximum deliverable force from a collision of isolated particles when one only is moving; and it is delivered only in case of head-on collisions. It is also fully delivered instantly, that is within unit-time. As for average, or unit density, it may be determined by anyone who can determine the material facts.

Two more units require definition—time (in terms of which velocity must be given before we can understand the amount of motion a body contains) and acceleration. Time, as has been proved, relates not to force-transfers, but to unaccelerated and unretarded motions through empty space. The unit of time may therefore be taken as that average duration which elapses before one unit-particle, when moving with unit-velocity through volumes wherein other unit-particles are spaced at unit-distance, strikes other motionless particles with a total effect equal to a single head-on impact. This definition seems complicated, but it is definite and meaningful. During unit-time in the average only one unit of force-expression is manifested, and except for this one full and instantaneous contact of particles, only empty space is traversed. Since the force-transfers themselves (when solids collide) consume no time, the entire duration which we designate as unit-time is consumed by the movement of a particle at unit-velocity through unit-distance.

In dynamics, therefore, unit-time is nothing more than the duration between unit-deliveries of force, and velocity is stated in terms of it for the sake of convenience. Time, as we know, does not participate in force-deliveries or in the surrenders of velocity. We need the idea of time in mechanics merely to prophesy the future series of events, or to translate to another person the course of a past happening. The amount of motion that a body possesses at any one period—its real velocity—is a quantity possessed independently of time and distance. It is as real a quality as the mind-power which a man possesses in addition to his purely physical body. Both velocity and mind-power can be realized in the practical relations of the world, however, only if they are represented in physical characters. Velocity should be given in terms of the distance covered in a straight-line by a moving projectile (or by the straight-line energy-translation through the series of blows of particles one with another) within a certain time, and mental powers must be measured also in terms of physical accomplishments—such as paintings, poems, or accumulated wealth. We perceive, therefore, why, for physical computations, we must measure an intangible "charge" of motion, or velocity, in terms of the time and distance consumed by the passage of energy, even though these characters do not participate in the accomplishments of this motion any more than the canvas and paint of the picture participate in the mental concept. Since the motion with which matter is "charged" is purely a mental accomplishment it should not require definitions in other terms to be understood by pure mind. It must, however, be described in terms of time and distance if it is to be made realizable in mechanics. In this transfer of values from one realm to another, we find it necessary to complicate the unit definition of mentally-given motion by imprisoning it between the two physical characters of time and distance, just as the beauty of an ideal conception may be imprisoned crudely on the canvas with colors, lines, and balancings of masses.

After velocity has been thus defined, the definition of acceleration becomes relatively simple. Unit acceleration is the increase of velocity given to a motionless unit-particle by another when the collision occurs head-on and at unit-speed. The unit of acceleration, therefore, is exactly one-half the unit of velocity.

Having determined our units, let us forsake these ideal but unrecognizable quantities for more practical considerations. What is the mechanical definition of force? The total potential force of a moving and composite body is proportional to the "charge" of motion that it contains, and this, in turn, is proportional, first, to the component-velocity in this direction of the particles composing the body, and secondly, to the number of particles in the body. If a composite structure has a velocity of ten feet a second, each particle composing it moves with this average speed. The potential force of each particle is therefore measurable as ten-foot-a-second units. If a body contains a million unit-particles, and if each particle has a force of ten-foot-a-second units, then the entire body expresses a force of ten million foot-a-second units. To obtain this figure in terms of a number of force-units, however, this product must be referred to the absolute unit of force, or to the mass-velocity of the unit-particle when moving with unit-speed—as the unit "one" (1) of the formulation. If the unit of velocity is the velocity of light-energy through space in one average direction (approximately 186,000 miles, or 186,000 × 5,280 feet a second), all force must be measured in terms of a velocity of (186,000) (5,280) feet-a-second. This, when taken in respect of the unit of mass, is the unit of force. For the sake of simplicity we shall represent this straight-line velocity of light-energy by the symbol c. True or "absolute" force, then, as possessed by a body moving in reference to the centre of the universe is proportional to the product of its mass (the number of unit-particles it contains) by its velocity in feet a second; but to resolve this into universal force-units the product must be divided by the unit of velocity, c. "Absolute" force is measurable, however, only as momentum.

The force that is potential in a moving body is not the force of our practices. We never experience nor have sensations from a body which forever moves by itself in empty space. We first become aware of a piece of matter when it strikes something, when it delivers part of its motion—or when we deliver motion to it. To be a real force-expression to us it must be a force *expressed.* And when the moving body collides with other bodies part of its "charge" of motion will either be destroyed or will be transferred to the struck body. We experience only that amount of total force which is transferred. How much, then, of the total force of a particle is deliverable on direct collision? How much of the potential force of a moving body, how much of its relative motion, may we experience?

The answer to this question has already been given. The result depends upon the circumstances. It depends upon the motions of the two bodies with reference to a fixed point at the time the collision takes place. A unit-particle moving at the velocity of light which strikes head-on another relatively at rest, will surrender one-half of its "charge" of motion. This, then, is the maximum quantity of momentum, or motion, or force, that is deliverable by this smallest bit of matter to a relatively motionless and equal particle. This force-transfer (at least when it is averaged into energy-translation in one direction) should be regarded as the unit of all energy-transfer. In doing the work of giving motion to an equal motionless body, the force actually delivered by the direct impact of a mass (M) moving at V speed equals ½ MV, whereas the potential force of the moving body before the contact equalled MV. To stop M completely, to extract from it all of its V speed, it must be resisted, not by one or more equal motionless bodies, but by bodies moving in an opposed direction—that is to say, by the parts of so-called "elastic" composite bodies. Of course, when two particles are moving in opposite directions, the relative velocity of the impact is more than V. If c is the speed of light, the maximum relative velocity of the collision is $2c$. When M, an inelastic unit-particle, moving at V speed, collides directly with another particle which is moving in opposite direction with a velocity V, the total force of the two will be cancelled. Each particle will then surrender its entire "charge" of motion, and each will lose a force, or motion, equivalent to MV—or 1V in case M stands for unit mass. Only when the force of a body moving at V speed is delivered completely,—that is, only when it has no relative motion after the collision,—will the amount of delivered force equal MV.

We perceive, therefore, that the force potential in relative motion is double the amount of force transferred by a mass-collision with an equal stationary mass. There are many intermediate stages of relative motions. Thus there are motions in the same direction, and also deflecting blows of varying intensities, but these need not be considered, for they do not enter into the basic formulas.

Every head-on collision between particles has a result complete in itself, and this result may be analyzed as if unconnected with preceding or subsequent events. The conditions surrounding a collision may also be gauged by an analysis of the influences of the environment upon the collision. For example, it may be definitely stated that *if* a striking body, A, surrenders all of its motion when it strikes a relatively motionless body of equal mass, B, there *must* exist in this environment some other body, C, which, although unperceived, is striking B from a direction opposed to the motion of A, and which, by the opposition of its momentum, is causing A to surrender all rather than one-half of its motion. And in every case that A reacts somewhat from B,—however large or solid B may be,—it may be known by this fact that the force of some (perhaps unrealized) moving C is then acting on A or B in unbalanced fashion and with sufficient energy to send A back the way it came. The significance of elasticity is involved in this theory.

We now come to the derivation of the kinetic energy formula. We must modify MV (the total potential force in a mass M moving relatively at V speed) to measure the force required to give unretarded motion to a body through space greater than unity and moving through surroundings in which the continuance of the motion causes a series of resistances to be encountered. Naturally, this amount of force will differ from the simple momentum that may be completely transferred from body to body in empty space within unit-distance—such a transfer, for example, as is illustrated in the collision of the rifle bullet with the ballistic pendulum, or by the gravitational blows against the balanced scale-beam. In doing work, simple or multiple, we do only one fundamental thing: We give a struck body a velocity through the transfer to it of part of that "charge" of motion which a moving body possesses. This motion always passes when one moving solid comes into contact with another. Nevertheless, there are two kinds of work, the single contact and the succession of collisions, or the work done within unit-distance and that done through a multiple of these units.

The thoughtful reader will note that we are here speaking in general terms of force as if it were never exerted except through the use of inertia, and by the passage of a "charge" of motion on contact of two inert bodies. We are assuming, indeed, what we hope to prove; namely, that forces supposed to be acting at a distance; forces delivered without physical impacts, without the use of inertia; forces such as gravitation, magnetism, and self-contained thermal motions, are not the realities they have been imagined to be. When properly understood, these force-phenomena, we believe, will appear as the results of the collisions of the conventional unit-particles within a pool of pressures.

Kinetic energy, like momentum, is a phenomenon of impact, but the kinetic energy formula measures the effect of a series of contacts in a certain environment. Composite work of a certain kind is measured as kinetic energy, and not as momentum. Not only is the struck body moved by one application of force, but it is moved farther and farther, or faster and faster, by repeated applications of unit force. Weight-force, the force used in physics as the measure of force, causes most of our motions and accelerations, and it results from repeated contacts. The total force of weight, therefore, is naturally measurable by the formula that measures the accumulation of successive momenta.

Now it is fairly obvious that a single application of force cannot maintain a constant velocity in an object passing through a field of inert masses which must be brushed aside. With the passage of time, and with the movement through space, more and more particles will be encountered, more resistance must be overcome, and, therefore, more force must be expended if the movement is to be continued without retardation. The need of more force, of more MV, develops as the motion of M becomes faster, and as more units of distance must be traversed during each second. This does not signify, however, that the application of force must itself be continuous in order that a constant velocity may be maintained in an object. The matter-particles are themselves discontinuous in every environment through which a body may move, so that the resistances to motion will always be encountered discontinuously. The resistance of every extended environment to a moving object builds up discontinuously. Indeed, according to our theory, even gravitational weight, the measure of force, is intermittently received, is cumulative in effect through time, and accumulates by certain unit-increments. How, then, on this assumption, shall we modify the formula of unit-momentum to express the total force—or kinetic energy as it will then be called—required to do the work of maintaining a certain velocity in a body as it passes through a field of intermittent resistances?

Let us consider a motionless and elastic particle of smallest mass. This object, B, will move, we say, when it is struck by another equal mass. This striking body we shall designate by the letter A. Now if A should move at a velocity of V into a head-on collision with B, the latter will immediately acquire a velocity equalling ½V. Let us now suppose that B must move through a world-environment, and that this environment is composed (as are all world-environments) of particles of like kind which may be regarded in the average (for continued motion) as relatively motionless. These latter particles we shall designate as C's. After B has moved unit-distance (as defined) it will be in head-on contact with one of these motionless C's, and, if B is permitted to collide head-on with a single C, the velocity of ½V which it acquired from A, will be reduced by a second contact to ¼V.

Assuming, however, that the velocity of B is to be maintained at ½V, how much force must be expended in this environment to assure this?

Surely more force must be expended in maintaining the velocity of B under such conditions than would be required if there were no C's obstructing its road. But how much more? Precisely that amount of force which will suffice to keep the path in front of B clear of the obstructing C's. This fact, then, gives us our clue to the derivation of kinetic energy formula. Within the average distance that B moves with a velocity of ½V before it tends to strike one of the C's with the equivalent of a head-on contact, there must be expressed in this same direction enough additional force (and expressed, too, where the C's are situated) to give each of the motionless C's in the path of B (one after the other) a velocity of ½V. By exactly this use of force in this environment will B be permitted to move freely. The summation of this force should be our correct formula for kinetic energy. It represents the amount of energy required to keep B from meeting obstructions to its initial motion.

Now the time and distance that B must travel before it meets the average C in its path will depend both upon the velocity of B and upon the average distance between the C's. The faster B moves, and the closer together the C's are, the more contacts each second B will have with motionless C's, and therefore the greater amount of energy must be extended to keep the path clear ahead of B so that it may keep moving at a certain velocity. This, in general, is the principle, and we shall now derive the formula by taking up specific cases.

If the C particles (each with mass M) are spaced two feet apart, and if B (with mass M also) moves two feet a second, unless its path were kept clear B would strike a C particle every second. To permit B to move without retardation through such a field, a force equalling (M) (4 feet a second) or 4 M, must be expended in this environment of the C mass in question every second. And, if B should be moving at a speed of four feet a second, then A would be obliged to strike the C's at a speed of eight feet a second. At this speed, however, B would tend to strike two C's each second, so the momenta of two A's moving at a velocity of eight feet a second will be needed to keep the path clear in front of B. This total force can be formulated numerically as (2)(A)(8) or A16, or M16. When, however, B is moving at eight feet a second, the numerical figure for the total force required to keep the path clear of C's will be (4)(M)(16), or M64. As will be readily observed, these numerical figures for the total force-requirements,—namely, of M4 for the speed of B of two feet a second, and of M16 for a speed of four feet, and of M64 for a speed of eight feet,—show a total force-application equal numerically to the mass of B (or M) multiplied by its velocity squared. As only one-half the total momenta of the moving A's is actually consumed in giving motion to the C's, we find that the total use of force to maintain a speed of eight feet a second in B is (½) (M) (64) or (½) (M) (8^2), or ½ (M) (V^2).

To maintain any certain velocity in a pool-environment, the total use of momenta, or of real force, may therefore be formulated as a summation of separate and discontinuous momenta. The total summation, in general terms, is found to equal $\frac{1}{2}mv^2$. This formula, however, takes no account of the separated places where the different energy-installments must be delivered.

It is assumed in physics that the formula for the energy of doing work may be taken in terms of the weight of a body, the weight being a supposedly fixed proportion of the mass for any certain earth latitude. It is usually supposed also that the formula for kinetic energy ($\frac{1}{2}mv^2$) is applicable to all earth-conditions, regardless of the velocity that is used in the formula. It is now known, however, that the velocity of light is the maximum velocity of straight-line energy-transmission in the universe, and it is generally supposed that neither impact nor attraction can increase it. The Einstein theory preserves the formula in face of the conflicting facts by regarding mass as a variable. I shall try to show later, however, that the Newtonian formula itself is incorrect, but that it is approximately accurate for the slower of the earth velocities that gravitational weight-forces create. The theoretical deliveries of force to the C particles to keep them clear of B cannot actually reach these particles in the calculated way when the velocity B approaches even approximately the velocity of the gravitational corpuscles which deliver the energy of weight.[1]

The formula for kinetic energy has been given for unit-mass, but it is the same for all masses. If the body to be moved contains ten of the smallest bit of matter, the energy to be used to maintain the velocity (V) of each one of the ten is equal to $\frac{1}{2}(1)(V^2)$, and the energy-expression for the ten units is measurable as ten times the energy-expression for the one. For this reason, the formula of kinetic energy as $\frac{1}{2}mv^2$ is true of any mass whatsoever.

As noted, the formula for kinetic energy has been derived from the formula of momentum. The sum of many different momenta has been computed (repeating momenta of similar intensities, such as weight-force exemplifies), as many as needed to maintain velocity in a body moving under the particular conditions of a resisting environment. The universe of our illustration is supposed to contain particles of matter spaced on the average at some specific but unknown distance. This assumption led us straight to the conventional working formula for kinetic energy, and this seems to prove that our assumption of uniformity in environmental conditions is accurate for those earth-phenomena to which the formula of kinetic energy does apply. Let us now try a different method of obtaining the formula, and see whether we reach the same result. Let us disclose the rate of energy-delivery by a freely moving body *to* a field of inert objects. Let us calculate the rate of its delivery of motion (or momentum) to the field of motionless objects as it moves along, colliding, losing velocity, and surrendering potential energy as it proceeds.

Let us suppose that B, a unit mass of M, is moving at eight feet a second (V) through an environment containing other motionless unit particles, or C's, which C's are so spaced that every one foot B will receive a resistance from them equal to a head-on collision. How much motion, or energy, or momentum, will B surrender each second to the C's which it strikes, and how will this force-delivery vary with its velocity? When B has moved $\frac{1}{8}$ of a second at a speed of eight feet a second, it will have traversed one foot of space, and will therefore have collided head-on with one C (or its equivalent). In $\frac{1}{8}$ of a second B will surrender to this motionless and equal mass one-half of its own velocity. B will then move at four feet a second and will have surrendered a velocity of four feet a second and a potential energy of 4 M. In one-fourth a second thereafter, B will have moved another foot, and will again collide with a C particle, and its velocity will be reduced to two feet a second. In another one-half second B will collide again, and it will move slower and slower as time goes on. It will surrender from its original velocity of eight feet a second a series of parts as follows: In $\frac{1}{8}$ of a second it will surrender $\frac{1}{2}$V; in one-fourth seconds thereafter it will surrender $\frac{1}{4}$V; in one-half seconds thereafter, $\frac{1}{8}$V; in one second thereafter, 1/16 V; and so on. B will never be brought to rest if the C's which it meets are motionless, but it will nevertheless move slower and slower as time passes. We are not so much interested, however, in the gradual retardation of B as in the rate of its surrender of force to the environment as it moves at different speeds.

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[1] We shall also consider later the effect upon the conventional kinetic energy formula of the fact that the forces needed to keep the path clear in front on a falling body must be delivered at points progressive in space. The conventional formula does not introduce this factor, as it properly should, because gravity is erroneously regarded as acting instantaneously—that is, as acting everywhere at the same time.

The amount of energy surrendered by B each second depends upon its velocity at that time. When moving at eight feet a second, it surrenders velocity (or momentum, or force) at the rate of four units in $\frac{1}{8}$ second, which is the same as 8x4 feet in a second, or thirty-two feet a second. The rate of surrender of momentum by B to its environment is therefore proportional to $\frac{1}{2}V^2$; for, when V equals eight feet a second, it gives up its velocity at the rate of thirty-two feet a second, which is equal to $\frac{1}{2}(8^2)$. When, however, V is sixteen feet a second, the rate of surrender of momentum is equal to $\frac{1}{2}(16^2)$, or 128 feet a second. It may be said, therefore, that the total amount of force obtainable from a moving mass, B, by other equal masses uniformly spaced, and relatively motionless in the environment through which B passes, is proportional to one-half the product of the moving mass by its velocity squared. The formula $\frac{1}{2}mv^2$, then, is the formula for the ability of the moving mass B to do work against other equal motionless masses uniformly spaced in the environment through which it is traveling.

We may now comprehend the true significance of force. The symbol MV represents the work done by a body M when moving at V speed against a relatively large motionless object where the greater part of the total potential force of the striker is absorbed in the collision; and the symbol $\frac{1}{2}MV$ represents the force delivered by a moving M to another equally motionless M in empty space. We see also why we can advantageously use the conventional formula for kinetic energy as $\frac{1}{2}mv^2$. Indeed, the formula for kinetic energy, by its very applicability to the work done by weight, by the fact that it subscribes to enumeration, proves to us that weight-force is composed of repeated momenta. Its applicability to earth-masses helps to prove also that within these earth-bodies the unit-particles, in so far as they affect the movement of another body, are in the average to be regarded, first, as uniformly spaced, and secondly, as if motionless. This does not mean, however, that all earth-bodies are equally dense, or that they offer equal resistances to the passage of another body, or that they really are motionless.

Each earth-element has its own density, its own structure, and its own amount of resistance to motion. Densities vary, but the more or less numerous particles in a body oscillate back and forth. Their localized motions inside the parent body, however, do not permanently affect the striking body, because these motions (and their momenta) tend to compensate each other before the striking body has completed its delivery of impact, and before an appreciable effect in one direction has been created by their temporarily unbalanced motions. If the averaged force-expression of the parts within the struck body always stands at zero with regard to sidewise motion, then the greater or less velocity of these particles will have no final effect on the motion of the average striker. The oscillating motions of the average particle neither impede nor accelerate the approach of the striking body. Only their dead inertia retard, so that normally the use of kinetic energy by the striker to create velocity in the struck body as a whole does not vary with the velocities of these oscillating parts. The resistance to approach does vary, however, in proportion to the total inertia (or density) of the struck body. More kinetic energy will be required to move the B mass through an environment of C particles if the latter are spaced one foot rather than two feet apart. Because of this fact, less energy is required to move a body at a certain speed through air than through water even though the particles of the air move faster than the water-particles.

Imagine a closed tank of water in which a large compressed air-bubble is immersed. The water and air will have the same pressures at the surfaces where they are in contact; there will be an energy-equilibrium between air and water; the air-particles will compensate with their increased velocity for their lack of numbers, but, regardless of this general energy-equilibrium, another body which is impelled through both water and air-bubble by a steady force will move faster through the air-volume. The resistance to passage is always proportional to the densities of the environment.

Now the fact that kinetic energy is derivable as the summation of repeated expressions of momentum proves that there is no distinction between the units of the two types of force. Momentum, like kinetic energy, is a real doer of work; but it is that force-quantity which a moving mass in free space possesses in virtue of a single "charge" of motion. It is a force, therefore, which may be delivered once only. It is usually delivered to some relatively dense object which it strikes, and so, normally, it will be transferred during some tiny distance and within a short time—during a time and within a distance so circumscribed, indeed, that the resistance of the object will not be increased by the inertias of other bodies in the environment. Nevertheless, in delivering its "charge" of motion to an object, the striking body does do work through distance.

Momentum, therefore, is a form of force; and energy is also a form of force. It is a summation of momenta. A bullet moving horizontally against a solid ballistic pendulum delivers only momentum to the pendulum. A bullet falling vertically, however, possesses kinetic energy also, because the gravitational blows against it accumulate and renew its energy through time. Thus it is provided with a greater force (as time passes) than the simple momentum which it possesses when moving horizontally, or when just starting to fall. Even when the horizontal bullet ploughs into water where its force is gradually absorbed, the total delivered force will be mv, and not $\frac{1}{2}mv^2$, but the energy will be delivered at the rate of $\frac{1}{2}mv^2$, and the force will do real work.

Whenever the event of delivering motion (or of doing work) is finished within unit-time-and-distance,—that is, before additional forces accumulate from the environment to the body doing work,—the momentum formula alone will measure the delivered force. The kinetic energy formula does not apply to such cases because it acquires its greater reality as a force-expression from conditions wherein experiences are prolonged sufficiently for additional force to be received from the environment. Hence the kinetic energy formula as given in physics is not appropriate for a situation unless the time-interval for the force-application has exceeded the real unit of time. In the case of weight-force, however, as already stated, the energy of the force does accumulate through time, and the force of weight, therefore, when taken for more than unit-time, does do work approximately according to the kinetic energy formula.

A man does work in water when he makes one stroke of his arm or leg, but this act does not make him a swimmer. He is not really swimming until by a series of strokes, reactions, and breathings he has succeeded in sustaining himself through time and distance. Each impulse against the water is the unit-event, whereas swimming is the protracted experience; and the two phenomena are different in formula even though composed of the same parts. Kinetic energy, likewise, is composed of unit-momenta multiplied. In reaching the phenomenon known as kinetic energy, simple momenta are delivered successively. This is the distinction between them; but it also makes for, and even establishes, the relationship of one with the other. As time goes on, as contacts occur, the momentum of a body moving horizontally on the earth's surface is a shrinking force; but the energy of weight-force is renewed from the environment. In each unit of time a weight receives a new "charge" of force in the form of a momentum. Its potential force-delivery does not lessen hour after hour, though it may disappear altogether during unit-time—that is, between the impulses which accumulate in the force known as gravity. The force which a weight acquires, therefore, must be regarded as a single gravitational blow whenever it is computed within a time-interval so small that no second gravitational impulse has been received. Obviously, however, the energy of weight must be formulated differently when the duration is such that many of the successive impulses of gravity are received by the object. In the latter case, as we have discovered, the formula of kinetic energy is appropriate. Energy is compounded of momenta.

When a weight is connected by a cord over a pulley to an object resting on a horizontal frictionless surface, the repeated impulses against the weight permit it to add a steady force of acceleration second after second to the sliding body, and, for the reasons just given, the energy of the acceleration may be computed with relative accuracy according to the kinetic energy formula. If, however, the horizontally moving object is being dragged through water, the cumulative momenta of the falling weight will finally be balanced by the accumulating resistances of the water-molecules. At some stage there will be no further acceleration. Here the energy of the weight-force will be balanced by the work done in forcing the object through the resisting water at uniform speed. The kinetic energy formula measures, therefore, not only the accumulated force-expressions of weight, and the rate at which the force of momentum is surrendered, but also the work done in maintaining the velocity of a body through an environment of continuing uniform resistances.

In creating motions in different environments, the conditions vary so much that the numerical formulations must be altered to suit the particular case. Nevertheless, although there are different degrees of resistances to motion—such as, for example, the different resistances of air and water—there are only two distinct classes of environment, the first being space absolutely empty (to be found only within very limited volumes), and the second being volumes which contain either motionless or moving masses. There are also two kinds of force-expressions—the unit, and the multiple. The two general formulas for force-delivery distinguish fairly appropriately between these two typical conditions. Environmental conditions which do not influence the unit-event do affect the protracted experience. Yet the unit of all experiences is the same. In general terms, therefore, the formula of momentum measures the force in all cases where the time-interval is so short that external influences neither increase measurably the amount of force which is imparting the motion, nor increase the resistances of the body receiving the motion. The time-interval must be longer than unity if more than the resistance of one unit-mass is to be encountered (fully) in the environment, or if more than one granular impulse is to be expressed by the weight-force which is causing the motion. From this clear-cut distinction we are able to perceive the significance of unit-time, and, in theory at least, can define it.

Many physicists seem to have encountered philosophical difficulties chiefly because they have made the assumption that there are force-expressions other than those derived from the contacts of moving matter-bodies. Gravitation, magnetism, cohesion, elasticity have all been regarded as types of power inherent in matter, which freely and continuously emanate from matter, and which, therefore, are characters independent of material inertias and solidities. The unreasonable concept of continuous force has confused us. When, however, these ‘‘forces at a distance’’ are otherwise explained, when they are regarded also as due to the intermittent blows of inert particles, we shall have taken an important step in setting our collection of concepts in order.

This chapter has probably proved difficult to the untechnical. Yet these mechanical considerations are important for we must understand what the motions of matter-particles signify if we are to verify our philosophy. Theories must be tested by their ability to support experience. Not only should the facts suggest the theory, but the theory should suggest logical explanations of the otherwise mysterious facts. We need before anything else a correct understanding of mechanical happenings, and a correct set of formulas to interpret them. We must, therefore, go a little deeper into the theories behind our everyday formulas in order to discover why and how these rules require correcting. But we must also attempt to explain all physical events in correspondence with our accepted definitions of Mind, of Matter, and of Evolution. Finally, a mechanical Relativity, a Relativity due to Evolution, must be added to our formulas if they are to be made to subscribe to reality. If our revised formulas do not then fit the facts, our philosophy will have been proved false. How necessary, then, that the philosopher consider these tiresome mechanical principles!

As Thomas Carlyle said in a letter to John Sterling:

> Nature and Fact, as you remarked, first tell a man the truth about his philosophy. Sow real wheat on the honest earth, you reap real wheat; sow chaff ever so *like* wheat, the earth receives it, but says nothing about it next year.

CHAPTER XXIII

THE TRUE SIGNIFICANCE OF SOME OF THE DISCOVERED LAWS

> The scientific law itself must, with every increase of our perceptive powers, return to the position of hypothesis and be anew put to the test of experience.
>
> KARL PEARSON.

AT the beginning of Chapter XXI the question was asked why the measure of momentum was fifty percentum greater than kinetic energy when the unit of velocity was taken as one yard a second, and fifty percentum less when the one yard was regarded as three feet. Believing that we now understand the difference between momentum and kinetic energy, let us see if we can clear up this difficulty. We are really concerned here, once more, with the significance of numbers as used in formulas.

The formula for kinetic energy, as has been shown, is derived as the summation of many units of force-deliveries, each expressed as mv, or momentum. It is the total amount of force required to keep the path clear ahead of a moving body when the inert particles in front of it are, in the gross average, uniformly spaced. The kinetic energy formula applies to a succession of force-deliveries inside a material pool as developed through extended motions, or in extended time, whereas the formula for momentum applies to contacts of similar kind in empty space, and also to collisions so abrupt that other energy cannot be received from the environment during the delivery of force. One law is applicable to movement through time or distance greater than unity and under circumstances wherein environmental influences have an effect; and the other refers to an occurrence completed so quickly or within such a short distance that the environment has no effect. *Per contra,* we have the right to say that unit-space (and by this we should mean the space to which the number ''one'' (1) may properly be given in formulas involving force-relationships) is that distance within which only the formula of momentum can apply. Any space-relationship may be taken as the numerical ''one'', or as the unity of space, but, with regard to force-expression, the specific distance to be represented properly by the number ''one'' *must be that within which there is only one delivery of force.* Only thus does the enumeration MV have conceivable meaning, for only thus is it the product of unit-numbers. If we select for number ''one'' (1) the distance of one mile, and refer to a velocity of one mile a second, the momentum delivered by a ten-pound mass moving at this speed will be the product of 10 x 1, and the kinetic energy will also be determined as though one mile were the unit of distance—that is, as if there were only one collision in that distance. In such case the deliverable kinetic energy is to be regarded numerically as (½), (10), (1^2), or 5, or as one-half the momentum of the striker.

On the other hand, if we use a number greater than unity (the number three (3), for example) to indicate the distance covered in unit-time (here one second), we then mean (or should mean), *by this very choice of numbers,* that three units of distance are traversed in the time of one second. This conclusion follows from the principle just stated—namely, that the ''one'' (1) of distance as it is used in our number-system in interpretation of force-relationships *must* represent the distance in which there is but one delivery of force. As an abstract statement, therefore, and also when translated in terms of a mathematics making use of a proper number-system, the formula (1M) (1V) signifies that within the unit-distance to which the unit-numeration ''one'' M and ''one'' V of the mathematical system may correctly refer, the momentum of the mass M moving at V speed is the measure of the total force deliverable by the moving body. The text-books say that momentum is the force-delivery within unit-time; but it would be more properly described as the force delivered within unit-distance when unit-distance is properly understood—and also *properly numbered.*

We come therefore straight to this conclusion: Whenever the velocity-factor in a formula measuring the delivery of force is describable numerically in terms of only one unit of time and of more than one unit of distance (such, for example, as a velocity of three feet a second), we may know *by this use of numbers* that the mathematical assumption has been made that there are three deliveries of force within the single unit of time. Every abstract numerical formula involving force-delivery is arranged in terms of number for the sake of convenience, but, back into any adequate number-system, the physical facts must finally fit. Only thus may mathematics have utility in translating mechanical events.

The numbers composing a formula measuring force-delivery indicate, then, that certain physical conditions obtain. Otherwise the formula would be inappropriate for translating the mechanical relationships. We learn, therefore (from the physical-mechanical implications of mathematics), from the choice of numbers in an abstract formulation that when the velocity is given as unit-distance a second (one yard a second) there is supposed to be (as mathematically interpreted and formulated) but one delivery of force within the yard. But, when this same velocity is *numbered* so as to indicate three unit-distances in unit-time, or as three feet a second, this very choice of a three-fold symbol for designating the distance informs us that the distance, as formulated, is broken up mechanically into three separate parts, and that, therefore, there are three force-expressions within the average second. This fact, in turn, indicates that three times as much total force will be required to maintain the velocity in such a field as compared to one in which there is only one unit of resistance. On no other terms can the general numerical formulation of mathematics be made useful in physics.

We perceive, therefore, that whereas kinetic energy is calculable as ½ M (or as one-half the momentum) when the M mass is moving at the unit speed of one yard a second, the numerical calculation of the total force-delivery to maintain the velocity in M must be three times as large, or 1½M, or fifty percentum greater than the momentum, when the velocity is summarized numerically as three feet (three times unit-distance) a second. Hence we find that the total force required to maintain a certain velocity is increased *in the proportion that the numbers indicating the number of units of distance traversed by a body within unit of time are increased.* This principle is fairly obvious now that we understand what kinetic energy is, and what the numeration of a formula signifies. Since the formula for kinetic energy is to be derived as a special case of the formula of momentum, the numerical relationships between the two, for different environments, become logical. That variation which previously seemed irregular and puzzling now appears to be reasonable.

The theory that the force delivered by unit-mass within unit-distance is measurable as a momentum, conforms also with other experiences, and even explains them. A ten-pound weight two feet from the fulcrum of a horizontal scale-beam balances a five-pound body at four feet from the fulcrum. Let us now inquire why weights are thus balanced whenever the products of the numbers of the weights by their respective numbered distances from the fulcrum equal the same quantity. And why do different weights fall *in vacuo* with the same velocity?

According to the theory that the weight of a body is due to the unbalanced blows against it of swift corpuscles moving in general towards the centre of the earth, a mass of 10M will be twice as heavy as a 5M body merely because the larger body receives twice the quantity of unbalanced blows during a certain time. Each M of the 10M body will receive the same number of blows of momentum as each M of the 5M body, so that each particle of each body will tend to fall at the same speed. The explanation of the corpuscular theory of gravitation is given in Chapter XXVI. Yet, if gravitational weight results from intermittent blows, there will be no accelerations during the intervals between the separate blows.

The weights resting on a scale-beam, therefore, while seemingly at rest, are not really so, for they are being struck intermittently by gravitational corpuscles, whereas these impulses, in turn, are being counteracted repeatedly by the upwardly acting momenta of the parts composing the fulcrum support. The upward impulses of the point of support always average the same as the downward impulses against the two weights during the same interval, providing this interval is sufficiently long. In the case of a falling beam, at the instant that the ground stops the descent the upward force of the point of resistance is greater than it is later when the weights have come to a condition of average rest; but the fact that the earth stops the fall, and then holds the weight-forces balanced, signifies that the upward force is able to and does balance all the gravitational blows moment after moment. This continuing elasticity of the earth is derived from the delivery of blows upon the earth-mass on the opposite side and in the opposite direction to the falling weight of our experience.

If two balanced weights are removed from a scale-beam at rest, it will rise slightly. The downward force against the ground—heretofore compressed beneath it—will lessen, and the atomic structures of the ground will attain a new condition of energy-equilibrium. The usual structural balance of the ground accords with the principle of a general energy-equilibrium, and the ground supports a weight in the same way that a mashed air-balloon supports a body resting upon it. Just as the molecules of the air-balloon are never at rest, but display motions in opposite directions which balance one another (and which balance the outside forces as well), so it is with the ground supporting the scale-beam. Although, in the average, the structural integrity of the earth-atoms is maintained hour after hour, nevertheless there is endless motion of parts—first downward, as the normal gravitational corpuscles strike, and then the reaction upward which restores the usual condition of equilibrium.

If a scale-beam with the two bodies resting upon it is placed upon a flat air-cushion, the beam will not remain level, but will press down into the cushion farther on the side supporting the heavier weight. If, however, the beam is rigid, and rests upon a fulcrum-point (itself supported by the ground or by an air-cushion) which presses up with a force sufficiently powerful and sufficiently often to compensate the weight-force of 15M, and if this resisting force of the support is applied two feet from a 10M body, and four feet from the 5M body, then the scale-beam will remain level. Since the fulcrum-point is twice as close to the centre of the side supporting the 10M mass, two-thirds of the upward pressure of the 15M (or 10M) will be delivered to the side of the beam on which the 10M mass rests, and one-third (or 5M) to the side of the 5M mass. The beam remains in average balance, because two equal and opposite forces of similar kind—both momenta—balance each other.

The upward forces of the atoms of the compressed fulcrum-point equal and balance the gravitational forces against the 10M and 5M bodies, but only when these gravitational forces are computed as momenta; and, since the atoms of the compressed fulcrum deliver their blows upward *intermittently* (just as the molecules of the air in the cushion strike the cover intermittently), we are obliged, from this fact alone, to conclude that the downward blows of gravity are received intermittently. Before the beam is deflected more than unit-distance by the forces acting on the 10M body, it is acted upon by two other forces,—namely, by a 15M force acting upwardly at the fulcrum-point, and by a 5M force acting downwardly on the opposite end of the beam. All these units of momenta, as received within unit-time, keep the beam level. Within unit-time the three granular forces may be conceived as acting only once. If the 10M and 5M bodies did not receive the gravitational blows in exactly this ratio they would not fall freely at the same speed through empty space, and if the upward force of the ground did not act in this fashion the beam would not remain level. The beam oscillates, therefore, but only within unit-distance, and the motion in one direction is quickly cancelled by a corresponding impulse in the opposite direction.

We now understand why a weightless beam remains level from moment to moment, provided that the products of the numbered weights by their numbered horizontal distances from the fulcrum point are equal, and provided that the units of weight-force are regarded as separate momenta. We are beginning to appreciate the significance of the statement already quoted from Professor Prescott that "The moment of this momentum about any point is the product of the momentum and the perpendicular on the line of the vector, that is, the line of motion."

Proof of the laws of levers, and of the momenta of weight-forces, has followed from a theory of gravitation which conceives of weight-force as being due, not to an application of continuous power in infinitesimal quantities, but to the intermittent blows of corpuscles. An infinitesimal force-unit is meaningless, just as an infinitesimal interval between forces is meaningless. We may say, therefore, that, rather, gravitation cannot be proved to be continuous, that all inferences lead to the conclusion that it is intermittent, and that its unit-effect does not subscribe to the formula of kinetic energy.

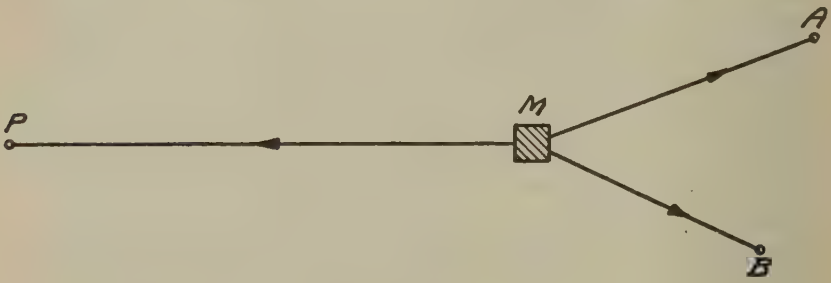

Fig. 1

We shall amplify this corpuscular theory of gravitation in subsequent chapters. Here, however, let us give our attention to a principle of force known in mechanics as the "parallelogram-law." Before it may be explained to readers having slight acquaintance with mechanics, it must first be described.

In Figure 1, a mass M is supposed to be held motionless by the tension of three rubber bands. One band "pulls" M along line MP towards the point P, others pull it along MA and MB. When lines MP, MA, and MB are plotted with their respective lengths proportional to the forces exerted by the "pulls" of the corresponding bands, and in corresponding directions, an important principle is discovered. By knowing the length of any two of the lines, the magnitude and direction of the third line (and of the force in this direction also) may be determined. Thus, if MA and MB are known, the direction and strength of that force acting along MP (which balances MA and MB) may be identified.

This computation is made by forming a parallelogram (Figure 2) with MA and MB as two of its sides. The line BC is then drawn equal in length and parallel to MA, and AC is drawn parallel to MB; the point M is connected with C (the intersection of AC with BC), and the diagonal of this parallelogram, MC, will then be found to have a length proportional to the force of MP—which latter, by the terms of our problem, is the force required to hold M motionless against the supposedly continuous "pulls" of the other two bands.

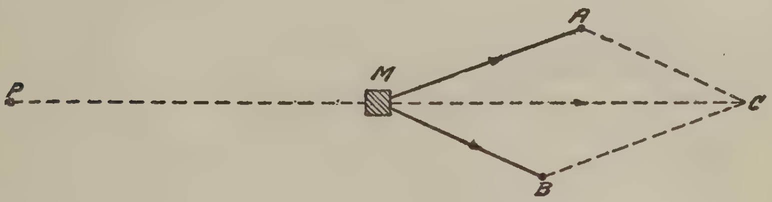

Fig. 2

The direction of the force MC, furthermore, is found to be the reverse of that of MP. The force represented by MC, moreover, is discovered to be as much greater than the force of MA as MC is longer than MA.

Now if the band MP is severed, the mass M will at that very instant begin to move along the line MC with the velocity to be acquired from the first application of a force proportionate to the length of MC. Of necessity, this beginning of motion is acquired from the very first impulses received from the forces of MA and MB. If, however, immediately after MP is severed, and after M has started moving, the two bands MA and MB are severed also, the mass M will continue to move along the diagonal MC with the velocity of its start. If, however, M is to continue moving along MC, and at this initial velocity, a duration of no more nor less than unit-time must elapse after severing MP before MA and MB are themselves severed. If all the bands are cut simultaneously, M will not move, and if the cutting of MA and MB is delayed, the direction of motion of M when finally released will not be along MC, and it will move with some other velocity.

The parallelogram-law was *discovered*, but the fact that this principle does fit in with practice should indicate something about the forces which are acting. By reference to it we should be able to confirm or disprove some of the classical theories. We should inquire, for example, what the state of affairs surrounding M must be that would cause it to move along MC after the band MP has been released for a duration of unit-time only. And why may this initial force be calculated as if M always started with one certain velocity? If we are able to explain these principles, we shall perhaps learn more about the nature of the forces themselves.

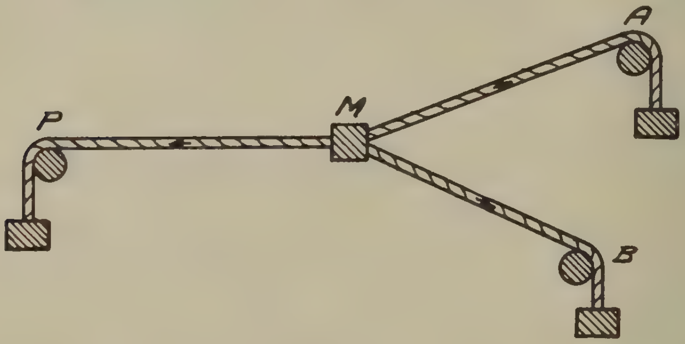

Fig. 3

Whether the forces MA and MB are caused by the tensions or "pulls" of rubber bands (figures 1 and 2) or by the "pulls" of cords attached to hanging weights (Figure 3), or by the pushes of rods pressed by air-cushions against M from three directions (Figure 4), or by combinations of these forces, M will, in every case, start to move in the same way, and according to the parallelogram-law. Does this not prove, then, that all these forces are identical in their unit-expression? If we may accept this conclusion as reasonable, we shall have made an important advance, for we shall have then associated under one principle types of force which are usually regarded as very different in nature.

When M is shoved by the three rods (Figure 4), the particles composing the rods strike M intermittently, for the atoms and molecules of the rods are separated like the air-molecules of an air-balloon. The pressing-force of the rods comes from the momenta of their many parts, and these deliver only intermittent blows. And if any one should be inclined to deny that the shoves of the rods are intermittent, a machine may be rigged which will maintain this same kind of equilibrium by blows that are obviously discontinuous.

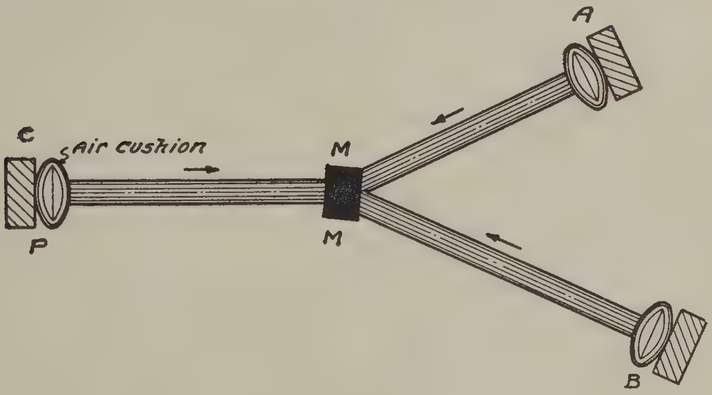

Fig. 4

For example, suppose one dispenses with the weights of Figure 3, and obtains this same amount of force with revolving fans which "pull" the ropes because driven by the separated blows of the air-molecules of the wind. Or, if we like, the fan may be operated by balls thrown against the vanes. In every case, whether shoved by the rods, or "pulled" by rubber bands, or whether the force is derived from suspended weights, or from fans driven by separated balls, the object M will always act in the same average way. This fact is most suggestive.

How is it possible that the motion of M will average the same whether it results from what is known to be a succession of discontinuous blows, or whether it is caused by forces like gravitation which scientists have usually assumed to be continuous? If gravitation were really continuous, it would be strange indeed that it should have the same average effect upon M through time as another force which is known to be composed of intermittent blows. Surely, two forces cannot be different—even opposite—in unit-principle if they give exactly similar results through unit-time!

Now in the case of the pushing rods (Figure 4) M cannot start moving in the direction of MC (after the influence of MP has been removed) unless during the first time-interval in which MP is ineffective, the particles of the rods MA and MB, or the air-molecules against the fan, actually strike M and deliver blows which are not counteracted by any influence of MP. After the force MP is eliminated, however, if M is to move along the line MC with a force proportional to the length of this line, forces proportional to the length of MA and MB must have been delivered to M during the *first unit time-interval*—and for no greater nor less time. M must be impelled by force MA towards A, and practically simultaneously therewith it must be impelled by force MB towards B. In such case (but this is true only if the forces of MA and MB are cancelled immediately after the delivery of one typical blow by each) the mass M will move along the line MC, a line which is derived as the resultant of the single unit-application against M of the separate and typical force-expressions of MA and MB. And yet this theory is unreal and meaningless when referred to a force supposed to be continuous, for there is no conceivable time-unit which could measure a definite amount of continuous force—an amount, that is, which could be depended upon to impart a certain definite velocity at the very instant of release. All force-delivery must be granular in mass and in time or the parallelogram-law would not suit the facts. We have reached the same conclusion through two distinct lines of reasoning.

The beginning of movement of M along MC must be compounded of two abrupt and characteristic "charges" of motion received during unit-time from the forces MA and MB. If, however, the typical impulses of MA and MB did not pass instantly, the motion of M would not be acquired so fully and so typically that it would invariably focus on the point C. If, for example, MA and MB are rubber bands and remain attached to M after MP has been severed, and continue to deliver force to M, its motion will then (if stopped and renewed at each point) follow the parallelogram-law from moment to moment, but each moment will display a different parallelogram, and a different direction of M. This fact proves that the parallelogram-law refers only to the component of unit and granular impulses received by M during unit-time.

The starting velocity, however, of M, and its first direction, do not depend upon the character of the forces MA and MB. If the influences of MA and MB are permitted to continue (without stoppage of the motion) for more than unit-time the final direction and velocity of M will depend upon the nature of all successive forces which have affected it up to the time of its final release from them. The forces of the pushing rods will come to an end relatively quickly, but the falling weights and rubber bands will act longer. The effect of all these forces at the outset follow the parallelogram-law, but only during unit-time, because, for a longer time than unity the different types of force vary in their typical expression. The falling weight repeats its force almost uniformly through time.

We have postulated that so long as three forces, MA, MB, and MP, act on M, it will remain practically motionless. From this we must assume that the typical impulses of the three forces in the average balance against M for any certain time-interval. The forces must balance as long as it stays where it is. The forces are present, they are real, they are delivered, but they produce no motion which we can say is finally unbalanced and displayed as work remaining done. Indeed, these repeated forces cancel one another without known compensations. No heat is generated, no radiations seem to occur, no permanent shifts of parts may be noted. Yet if the blows from the three different forces, even though they average the same throughout considerable duration, or even throughout that duration known as unit-time, are not received at exactly the same instant, M will quiver slightly. It will oscillate, but through such a tiny range that its motion will not be noticed. Nor will its *average* position be changed.

Here then is M, quivering imperceptibly from the blows received from three different directions at different instants —blows which balance one another, not during the instantaneous period of receipt, but during a longer, or unit-time. It is even possible, as already suggested, to arrange the mechanism so that M will be balanced by forces received at such long intervals that the quivering oscillations will be perceptible. The fact that the vibrations of M become perceptible, however, would not change the principle. The activities against M would still be balanced, and would still subscribe broadly to the parallelogram-law. M would remain balanced while the opposed forces gave it perceptible movements and while each did conventional work upon it. Yet none of this energy would display final accomplishment, nor would there be disclosed any compensations in terms of heat-radiations, permanent shifts of parts, and so on. The temperature of M is not even increased by the usual energy-delivery maintaining a state of equilibrium. Apparently, the energies of all these forces are destroyed without compensation just as in the case of the columns supporting the roof.

This much for the balanced state. When the force acting in the direction of P is eliminated, M will receive during unit-time the typical unit-forces of MA and MB, and will therefore start to move in the direction of C in response to their composite influence.

Now the first motion of M, as we have said, is the same whether the forces acting against it are realizably intermittent pushes or supposedly continuous "pulls"; for the so-called continuous "pulls" are not really such, but are tendencies to movement derived from swiftly moving and unperceived particles of matter. When a rubber band is in "tension"; an intermittent and unbalanced force is then acting to restore the old structural pressure-equilibrium that has been disturbed. These unbalanced forces of the rubber bands are neither continuous nor ''pulls''—no more than the forces of a vacuum-cleaner are continuous or real ''suctions.'' The dirt rushes into the hose of the vacuum-cleaner, not because it is ''sucked'' in continuously, but because the intermittent blows of the outside air-molecules push it into the volume of reduced pressure within the cleaner. These separated and discontinuous air-particles force the atoms of dust into the hose by ordinary momenta. Nature displays ''no suction'', ''pull'', ''tension'', nor ''attraction'', continuous or otherwise.

Inert matter-particles possess no force which they can express in the space exterior to themselves. The power of the smallest bit of matter is limited to the possibilities of its definition; and the definition of this ''thing-in-itself'' includes only those qualities which are within its own volume. Only those qualities within it belong to it. If they could be expressed outside, as some assert, they would then belong to that outside. The matter-particle possesses within itself its character of inertia. It also occupies, and thus controls, a certain volume of space. Its entire ability to deliver force, furthermore, seems to be derived from these two attributes, inertia and solidity, and they become effective when a contact occurs. They cannot be expressed at a distance. The particle cannot project its internal characteristics or cohesions outside of itself, through empty space, and thus affect other matter-bodies. We are attempting to prove this principle as we proceed, and to show from time to time that the contrary hypothesis is inconceivable.

Let us regard the so-called ''tensions'', then, as unperceived momenta. The impulse given M to move towards A by the rubber band MA is due to the blows of invisible particles, which, while they press in every direction, have a greater than normal effect along the line MA. When in ''tension'' the rubber band is like an air-balloon that has been mashed. The elongated balloon is not ''pulling'' when its shorter axis tends to lengthen so as to restore the spherical volume, but is merely receiving more pressure from the outside in the planes parallel to its shorter axis. For this reason it can deliver more force along these planes, and can support a weight day after day. When the weight is removed, the shortened axis will tend to lengthen (and the longer axis to shorten correspondingly) until the structure again becomes balanced with the normal environmental pressure—and until these pressures are again being received (and resisted) in like amount from every direction.

The stretched rubber bands tends to return to a structural equilibrium with its environment (the normal state of equilibrium having been disturbed by the stretching), and the force with which this tendency to change is expressed comes from the blows of invisible particles, which, by their motions, adjust and equalize all the pressures. When the particles composing a body have a certain arrangement, the blows have more effect upon the structural formation from one than from some other direction. By making a steady use of this unbalanced receipt of energy the structure is itself enabled to express what seems to be a constant force of its own (tension in the case of the rubber bands, or ''suction'' in the case of the vacuum-cleaner, or expansive pressure in the case of the mashed balloon), but this energy-pressure really arises from a series of impulses received by the structure from the outside in unbalanced and intermittent fashion.

A sheet of rubber stretched taut will support a weight placed upon it with less compression than a flabby outstretched sheet, yet the mass of rubber and its average density is approximately the same in both cases. In resisting the momenta of the weight-forces the sheet of rubber acts in the same fashion as the mashed air-balloon. Every piece of stretched rope does the same; also every tension member in a steel girder, and every other mechanical contrivance which is supposed to ''pull''. The ''pull'' is invariably an unrealized push. ''Tension'' is not a new kind of force; is not something developed out of nothingness, emanating from within the structure and then expressed outside; is not an unlimited power derived from thermal motions; is not an ''attraction'' at a distance; is not an indefinable, mysterious power of inert matter; is not a new kind of energy beyond understanding; but rather it results from the momenta expressed so unusually in a certain direction as to develop unbalanced, unsymmetrical tendencies to movement within the stretched parts of a piece of matter. This unbalanced energy is received from the outside, from the blows of the invisible particles moving with enormous velocities through the open spaces, and which, like the water-molecules in a pond, move because they have received motion (directly or indirectly) from the Power which restrains the universe within finite bounds.

Because the so-called ''pull'' is not really a ''pull'' but a push, its force accords with, and can be formulated under, the principle of momentum. The parallelogram-law, by demonstrating that all types of forces, during the first unit-interval of typical expression, whether supposedly ''pulls'' or really pushes, may be formulated in the same way, supplies strong proof that all forces are delivered as momenta.

The concept of a restrained energy-pool of equilibrium, the parts of which move unceasingly and strike each other discontinuously, solves, many of our difficulties. In such a universe no part will remain motionless, no more than water-molecules will stay at rest in the lake, nor the air-particles in the balloon, nor the electron in the atom of hydrogen. All matter-bodies move, contact at intervals, and deliver momenta intermittently to other bodies. Within certain of the denser bodies, however, the parts move only tiny distances. Here the pressure-restraints which reverse the motions of the atomic parts are so tiny, so swift, and so frequent, that the path of oscillation of the parts (the parts of the usual solid) is so minute that it is indetectible. In the old days the oscillation was denied; now it can be no longer. Nevertheless, the oscillations caused by the blows of gravity are still doubted—for they are not often detected. And when detected, as in the ''Brownian'' movement, they are otherwise explained.

Gravity is usually regarded as an unceasing pressure which steadily holds the moving parts of a stone against the moving parts of the ground underneath. It is not supposed that the parts of the stone first press into the ground, and then retreat, and thus oscillate unceasingly as and because gravity and other exterior forces deliver their blows intermittently. Indeed, when a particle of matter oscillates sufficiently for its motion to be observed (as the electron in its atomic structure, or the molecule in a small volume of gas) the scientists can give no explanation of the phenomenon. The ''Brownian'' movement (supposed to be due to a heat-agitation which has no known energy-source) affects every particle of matter, and every larger congregation of similar particles. The Brownian movement proves that, *in practice,* in physical experiences, and even according to the criterion of the classical mechanist, the force of gravity does not hold a particle of matter continuously against the earth. Whenever gravity acts, whatever body it influences, the pressure is discontinuous. Unexpected ''thermal'' motions prevent gravity from accomplishing that continuity of effective force that is postulated for it. Why not admit, then, that in practice the effect of gravity is not continuous? And then, why not accept these constant ''thermal'' motions as really being the expressions of universal forces—as the appropriate movements of the parts of a body by which the energy-expression of the pool is maintained in all its volumes.

The facts being as they are, physicists cannot prove that a force which does *not* succeed in holding every particle continuously against the earth, is a continuous force. Now that our microscopes are more revealing, experience sets against the conventional belief. In this difficulty, confronting facts that contradict assumptions, the physicists attempt to explain the failure of gravity to hold matter to the earth unceasingly by telling us that the force of reaction comes from ''thermal agitation''. To which one may reply that this is no explanation, and that experience proves that the effect of gravity is not continuous.

Professor Gilbert N. Lewis says:

> Do you believe in miracles? Let us consider a box with a one-gram weight resting on its floor. Let us place this box in a bath maintained at an extremely constant temperature, we will say 65 degrees F, and let the whole be protected by the most perfect mechanism that we can

think of to shield it from external jars. Let us, in other words, shut it off from all external influences, leaving only a small hole through which we may observe. We may look into the box millions of times and always find the weight upon the floor, and we then state this to be a law of nature. But the time will come when we look in and find the weight some distance from the floor. It will not happen often, but we can calculate with a high degree of accuracy the chance of finding it, let us say, ten centimeters or more from the floor. This chance is so very small that I cannot express it in any ordinary way. We state chances as fractions, but to denote this chance I should have to put down a decimal point and zero after zero, and should spend my whole lifetime before I could write down a number not a zero. But the calculation is none the less correct.

The chance becomes larger if I consider the smaller weights and lesser heights from the floor. Let the height be one hundred million times as small and the weight also one hundred million times as small, and then the calculation shows that if we look every second we shall find the weight as far off the floor as this 6.32 times in every million years. If you bet five to one on the appearance of this phenomenon in a million years, you might lose at first, but you would come out ahead in the long run.

If we take a still smaller weight the chance goes up very rapidly, and if we examine particles which are just visible with a good microscope, we find them hopping about in what is known as the Brownian movement, and which we now know to be identical with that thermal agitation which all molecules or groups exhibit, and which always increase with increasing temperature. From a study of these movements Perrin was able to draw some extremely important deductions with the aid of the same formula as I have used in these calculations.

If the jumping of one-gram weight was a miracle, here in the Brownian movement thousands of such miracles are constantly occurring before our eyes. It is not true that things left to themselves approach a constant state, but only that they approach a state which ordinarily appears constant to us because of the dullness of our perceptions.[1]

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[1] G. N. Lewis: *The Scientific Meaning of Chance,* Yale Review. July, 1926, pp. 678–9.

Although Professor Lewis says that this movement is identical with thermal agitation, he remarks elsewhere in this article:

> The validity of thermodynamics is independent of mechanics. In fact, the science of mechanics is not altogether satisfactory; a study of the specific heats of substances has shown that it is necessary to make some changes in the assumptions of mechanics, but we do not yet know what change must be made.

This is almost sufficient admission. But Professor Lewis goes on.

> The second law of thermodynamics has come to be regarded as one of the most powerful and inexorable of nature's laws. It is beginning to dominate chemistry and the biological sciences, and its sway extends from the pure sciences into various domains of technology. Now, however, that we have looked behind the scenes, it almost seems as though it were all a sham, like some silly clown garbed in the ermine of royalty. Stripped of its finery, we find that the second law states that if a pack of cards is thrown in a shuffling machine the chances are that it will be shuffled.

All of this proves that the explanation of the release of particles from the bottom of the box against which they were at one time mashed may as well be explained by the theory that gravitational forces are discontinuous. Certainly, one does not improve his position by saying that the effect of gravity would really be continuous except that thermal agitations, with an unknown source of energy, prevented it from being so. For some cause or other gravity does have a visibly intermittent effect. This much must be admitted.

One should now be ready to believe that every tension is the result of intermittent and exterior blows. Belief in continuous force quickly develops its own paradox, just as the concept of any mechanical force other than that due to inertia of a moving particle quickly develops its *inconceivabilities.*

We shall now pass on from this description and explanation of the parallelogram-law, and of the nature of so-called "tensions". Later we shall consider other interesting mechanical phenomena. We know for example that the force-expression of a weight, when prolonged beyond unit-time, may be taken as a fairly accurate unit in the formula of kinetic energy. Why is this so? How accurate is the formula of a force that uses the weight of a unit-body as its unit of force? And should our theory of force add any Relativity to our formula of kinetic energy? We use this formula, and find it fairly practical in commonplace experiences, but does it require revision to make it definitely accurate? If it is to be revised, what factor of revision should be used?

In the following chapters, we shall try to answer some of these questions, basing our reasoning upon the belief that gravitation is due to the unbalanced blows of invisible particles, and that the force of gravitation is derived as a product of Evolution. We must consider this theory of gravitation in detail, so as to see if it fits in with the facts.

CHAPTER XXIV

THE REAL MEANING OF A POUND OF FORCE

Aesthetic elements being excluded, the mechanical reigns.
JOHN DEWEY.

IN *The Theory of Relativity,* Professor Einstein briefly discusses the meaning of gravity according to his Relativity hypothesis. He speaks as follows of an "attraction":—

> If, for instance, a magnet attracts a piece of iron, we cannot be content to regard this as meaning that the magnet acts directly on the iron through the intermediate empty space, but we are constrained to imagine—after the manner of Faraday—that the magnet always calls into being something physically real in the space around it, that something being what we call a "magnetic field." In its turn the magnetic field operates on the piece of iron, so that the latter strives to move towards the magnet. We shall not discuss here the justification for this identical conception, which is indeed a somewhat arbitrary one.[1]

Professor Einstein remarks that this picture permits of a more satisfactory theoretical representation of electromagnetic phenomena, and that "the effects of gravitation also are regarded in an analogous manner."

Let us picture gravitation in somewhat the same but in a more specific fashion. Something primary happens which creates an "absolute" Evolution of matter, and in this Evolution inertia is destroyed. The energy-expression of a certain volume is thus reduced below the average of the pool. This may be done of a piece of iron (then called a magnet) by removal of some of the atomic parts of its previously balanced energy-structure, or it may be done in respect of an earth by the destruction, or withdrawal to an unmechanical realm, of some of the inert substance of its volume. The reduction of the normal energy-expression of a structure by the dissolution of some of the usual inertia within its volume serves to permit the movement towards and not away from it of other matter-bodies in the neighborhood—just as the reduction of density within a vacuum-cleaner, followed by the corresponding lessening of its ability to resist aggressions, induced the average dust-particle in the neighborhood to be brought nearer. ''Suction'' towards a volume is the name for a state of affairs which results in more ''push'' or pressure, being expressed in the direction of that particular volume in which counteracting forces are then less than normal. A vacuum-cleaner is ineffectual unless inside an energy-equilibrium pool of air-molecules normally pressing in every direction. A ''field'' of ''attractions'', correspondingly, is the name of that space wherein there is a lack of the usual universal energy-deliveries.

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[1] Albert Einstein: *The Theory of Relativity,* p. 63.

Professor Einstein says: ''The earth produces in its surroundings a gravitational field, which acts on the stone and produces its motion of fall.'' This is doubtless true, in one sense at least, although the earth does not produce the ''field'', but the more important inquiry relates to the first Cause which, by its activities, does create the state of affairs which gives rise, in the earth and elsewhere, to the unbalanced energy-state known as attraction. Gravity appears to be a phenomenon exemplifying spiritual causation, and because I have reached this conclusion I cannot accept a theory which, like Relativity, seeks the explanation of gravity in terms of a new category of materialistic definitions.

The General Theory of Relativity treats of a principle that Professor Einstein says ''has hitherto been recorded in mechanics, but it has not been interpreted.'' It is the law that ''The gravitational mass of a body is equal to its inertial mass.'' It is found from experience that ''the acceleration (of a certain mass) is independent of the nature and condition of the body, and always the same for a given gravitational field'', and, therefore, ''the ratio of the gravitational to inertial mass must likewise be the same for all bodies.'' Professor Einstein says that we cannot interpret this principle satisfactorily unless ''we recognize the following fact: The same quality of a body manifests itself according to circumstances as 'inertia' or as 'weight' (lit. 'heaviness')''.

Chapter XX of The General Theory of Relativity is entitled *The Equality of Inertial and Gravitational Mass as an Argument for the General Postulate of Relativity.* I shall not consider this discussion more than to say that Professor Einstein regards what appears to be a gravitational ''pull'' as perhaps due to the resistance of an inertial mass to a constantly accelerating force—the type of unbalanced force that, even in the absence of gravity, would affect an object while lying upon the floor of an accelerating elevator. If the elevator should continue to rise faster and faster forever, the bodies of people inside would never fail to be pressed against the floor, and the force of the pressure would be a derivative of that energy which supplied the constant acceleration. If, however, the passengers were unaware of the relative increase in velocity, if they could not see outside the elevator box, they would be unable to explain the continuing pressure downward of their bodies against the floor, and would naturally conclude that the floor was steadily ''attracting'' them. This force relative to the floor of the elevator, which they would misname an ''attraction'', would, for a constant acceleration, be expressed in a constant ratio to the inertial masses of their bodies. The fact that this theory seems offhand to suggest why the gravitational mass of a body is constantly proportional to its inertial mass, makes Professor Einstein give it some tentative credence. He thinks that perhaps we have mistaken the effect of acceleration for ''attraction''.

Yet this theory introduces more mysteries than it dissipates, for the source of the energy which gives the constant acceleration is not identified; nor is an explanation given for the directional opposition of gravitational pressures as they are felt in different parts of the earth. Nor does Professor Einstein explain how gravity might be less on the moon than on the earth while these two planets keep their average relative positions in general space. They move together as parts of one permanent solar structure, so that, according to his theory, their gravitational fields should be of equal strength. These are unexplained contradictions of the theory by the facts.[1]

Professor Einstein does attempt, however, to show, through another implication of his theory, that the elevator may be regarded as at rest in an "absolute" sense even while "it is being constantly accelerated with respect of 'Galilean space.'" This explanation is even more inconceivable than the idea of a force acting at a distance. But let us not further explore these matters, for perhaps we can dissolve the mysteries more easily by suggesting new hypotheses than by attacking the old. When we have sufficiently analyzed the relatively simple "Evolutionary Theory of Gravity", and when we understand the laws governing the motions and forces of corpuscles as they tend to concentrate upon those volumes wherein matter has dissolved unusually, we may find that we do not require the puzzling Relativity Theory to understand the laws of concentration, and to realize why the gravitational and inertial masses of a composite are almost (but not exactly) identical.

According to the Evolutionary Theory, gravity is derived from the inertia of invisible corpuscles striking with unbalanced force against a so-called permanent structure, or element, and thus tending to drive it towards another relatively dense and relatively permanent structure. The unbalanced momenta of the invisible corpuscles of the universal energy-pool is a force-expression secondary to the dissolution of matter—a dissolution which takes place abnormally, we contend, in the relatively denser volumes of the more permanent structures. Except for the relative excess of vacuum-creating in the denser masses there would be no unbalanced movements towards these volumes. "Attractions", therefore, are compounded of the momenta of corpuscles against an object in unbalanced fashion, but these movements are themselves due to that dissolution of matter which takes place unusually in the denser volumes. There would be no movements of concentration even in the presence of vacuum unless the vacuum was created within a pool of particles moving under impulsions from a restraining and moving Cause of general concentration. Only within the bounds of such an energy-pool would the creation of an abnormal mechanical vacuum in one spot be followed regularly by an unbalanced movement concentrating on that spot.

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[1] A careful consideration of this subject and a suggestive interpretation of Professor Einstein's views may be found in Chapter XXIV of *The Evolution of Scientific Thought* by Mr. A. d'Abro, and I refer the reader to these valuable pages.

The vacuum-cleaner is effective because it is surrounded by the pressing air-molecules of the room, molecules oscillating under restraint while being impelled here and there. These molecules themselves normally receive equal resistances at bounds from every direction, and hence, invisible though they are, they respond to every reduction in the usual resistance from one direction. For this reason, they rush quickly into the reduced pressure-volume of the vacuum-chamber. Operate the most powerful vacuum-cleaner in the world inside a tank empty of air, and its air-vacuum will not appreciably affect the neighboring particles of dust. The concentration toward the vacuum-cleaner, therefore, is due in one sense to the unbalanced momenta of invisible air-molecules, but the reduction in average pressure, which is the real cause of the movement, is itself due to conditions created within the machine. Here, through a process of reducing the densities of the air, the resistances to the aggressions of the surrounding pressure-pool become less than normal. The process within the machine is not the first cause of the motion, however, for there would be no movement except for the surrounding pressures. The first cause of that unbalanced tendency to motion which we call Gravity, therefore, is the Power which creates the restricted energy-pool with its inert and moving parts. The Evolution of matter is but a secondary cause of Gravity, and the primary cause is attributed to a mental power. Here, however, we are discussing solely the secondary cause of gravity, for it is the first link in the chain of the purely mechanical sequence with which we are dealing.

Now if Gravity is due to an unusual vacuum-making within an otherwise balanced pressure-pool, and if the dissolution of matter takes place unusually in the denser masses, we perceive that the ''field'' of concentration about any object will be proportional to its relative excess of mass-density as compared to that of an equal average volume of the surrounding pressure-pool. We perceive likewise that the ''field'' of concentration surrounding the vacuum-cleaner will be stronger in the proportion that the energy of the motor which creates the vacuum is greater. Still, even though this be granted, one cannot readily see why a relatively dense object will be forced towards the vacuum by the surrounding air with a force which is proportional to the mass rather than the volume of the object. It is this principle which Professor Einstein endeavours to explain with his hypothesis that the seeming ''attraction'' is like the force that would arise from an unperceived but constant acceleration.

When one accepts the corpuscular, or evolutionary, theory of gravity, it will be possible to understand why the denser mass receives more of the unbalanced gravitational impulse than the lighter mass of equal volume. We shall reserve this explanation, however, for the chapter devoted particularly to gravitational laws. We are more concerned here with the mechanical aspects of force—and especially of weight-force. The pound of weight is our conventional unit of energy, and if the corpuscular theory is sound it should clarify our ideas of weight-force, and should define the true unit of weight (and of force) to us.

Thus, at the very start, we learn from the corpuscular theory of gravity that, in any one ''field'', gravitational and inertial masses are not absolutely proportional. The postulated law of every-day physics is true only approximately, even of the semi-permanent structure composed of similar building blocks, and of objects relatively at rest in respect of the centre of the ''field''. It applies closely only to objects at a relatively great distance from this centre. According to the corpuscular theory, the effect of gravity on an object should vary in some ratio with its speed towards the earth, and should disappear altogether when this velocity equals that of the speed of the effective blows of the corpuscles themselves. While the force of gravity with which a ‘‘field’’ acts on an object does reduce inversely with the speed of the object towards the center of that ‘‘field’’, the inertial mass of the object is nevertheless unchanged by its relative velocity. The momentum, or energy of its motion, the stored-up force, whether the object is moving horizontally or vertically, is always directly proportional to its mass and velocity —and this is so regardless of how great this velocity may be. We have discovered that the energy stored in a body moving horizontally through a field of stationary objects is always surrendered to the ‘‘field’’ at a ratio which subscribes exactly to the conventional formula of kinetic energy, although the kinetic energy of a falling weight is not directly proportional to $\frac{1}{2}mv^2$. The weight-force of an object towards another one supporting it against gravity, varies in a proportion to the velocity in the direction of the gravitational centre, becoming zero when this velocity (v) reaches a certain maximum. The disclosures of these errors in our old Newtonian laws of energy come directly from the corpuscular theory of gravity, and we shall find that it is quite unnecessary for us to introduce as explanations the conflicting and puzzling ideas of variable Time, variable Mass, and curved Space-Time.

The corpuscular theory informs us, too, that the strength of a ‘‘field’’ does not vary in exact ratio to the square of the distance. For this reason the proportion between inertial and gravitational mass in each ‘‘field’’ varies slightly with every change in the distance from the centre of attraction. We shall learn also that when very tiny bodies are moving with enormous velocities, they are affected by the gravitational field so little and at such long intervals that each influence of the ‘‘field’’ is a different proportion of the inertial mass. A body may even escape completely from a certain effective gravitational field without being influenced by it. Indeed, the gravitational mass of an object disappears entirely at a point situated between two equally ‘‘attractive’’ fields. An object is then like the donkey between two equally tempting bundles of hay. It has no unbalanced tendency to gravitate to either. It has its customary inertial mass, but no gravitational mass, and the proportion between the two masses has become zero. If the dissolving world were uniformly dense in the sense that the unit-bits of matter were in the average uniformly spaced throughout its volume, there would be no gravitational mass, but inertial mass would remain exactly as it is.

The conventional laws of energy contain error, therefore, but in ordinary practice the percentage of error is so minute that it is not usually perceived. Only when we treat with the tiniest bits of matter do we discover that they do not respond to the theories or to the gross rules of the conventional text-books. In such cases, some of the modern scientists have been willing to accept the Relativity theory as an explanation of the discrepancies. We complain, however, that these explanations of Relativity are not only unintelligible, but are also self-contradictory. Therefore they are unsatisfactory. Certainly, if an evolutionary theory of gravity will give us more consistent explanation we should welcome it. Yet the ability of the Einstein hypothesis to give an explanation of the variations now discovered in the Newtonian laws has been the chief factor in its provisional acceptance. In some cases Relativity has proved practical, and this utility has been its claim to value. Its assumptions, when made to fit the facts of a certain experience, have coincided with this experience. While philosophically unreasonable, and while contradictory to other facts of experience, and while denying the reality of the type of the mental power which conceived it, the Relativity Theory is still accepted by those who see the need of something, who see that Relativity can be made to fill certain gaps, and who have not yet discovered another theory more self-justifying or more reasonable.

Now this book represents one of the many attempts that are being made to supply a consistent theory and explanation of mechanics and of life. It seeks to demonstrate the presence of a mental Cause of motion, of energy, of Evolution, and of Life. In these chapters the attempt is being made to identify this spiritual Cause in the very heart of physics.

Relativity denies a mental source of mechanical activities. It tries to supply a quasi-mechanical explanation of certain mysterious variations in mechanical principles. It still purports to cling to mechanical Conservation, and thus denies mechanical Evolution. But Relativity is not an explanation; it is merely a statement and a formula. If one wishes to prove the reality of Reason, and the power of that from which Reason springs, it is imperative, then, that he should point out the inconsistencies of Relativity, and of mechanical Conservation in general; and he must also introduce into physics the theory of a mentally driven Evolution. He must prove, too, that this different theory dissipates the present mechanical mysteries, and corrects the mechanical formulas to the end of making them consistent.

Here then, in the midst of mechanics, at a time when we are endeavouring to define our mechanical units, and when we have taken the hypothesis of the transmutation of matter as our postulate of the cause of the unbalanced motions everywhere about, let us consider (and particularly in the light of this theory) the meaning of the term ''a pound of weight'', or ''a pound of force''. Let us see if our theory throws a new light here, and gives us a clearer definition.

A piece of lead weighing a pound in the earth's field is composed of a definite but uncounted number of the smallest bits of matter. This ''pound of mass'' receives each second from its environment a definite amount of the unbalanced momenta of the invisible gravitational corpuscles of the earth's field. The unbalanced momenta of the invisible strikers are transformed into the repeated momenta of the visible object —the pound of mass or weight as it is called. The momenta of the stream of corpuscles are transferred to this pound body instantly, and intermittently, and, second after second, the delivered energies accumulate in it unless otherwise compensated. For this reason the falling body moves faster and faster up to a certain maximum velocity. A pound of energy is virtually a pound of accumulated momenta thus received from the environment at a definite rate through time, and is that total amount of force which, when fully delivered at the earth's surface to another mass of a pound, will within a second give this object (on our earth), if unresisted, a velocity of approximately 32.16 feet a second. We may say, therefore, that the momentum of a pound of matter, when moving at a velocity of 32.16 feet a second, equals the totality of force which within one second is transferred (as a series of momenta) from the invisible corpuscles of gravity to a pound of mass. If the pound of mass is falling freely, these momenta, after being transferred, represent force stored in the moving object, and the falling body must completely discharge itself of this force (or motion) to some other mass before its movement can cease.

If a body in a gravitational field rests against the solid ground, and does not accelerate by falling, it will continue to receive the forces of the gravitational "field", but the series of blows will not create extended motion nor increasing velocity in relation to the centre of the earth. When the object rests against the earth, it receives (unit after unit, and invisibly) from the elements composing the earth counteracting blows of corpuscles moving within the atoms in the direction opposite to gravity. Some blows are received in opposition to gravity even when the body appears to be falling freely; for, otherwise, the maximum speed of gravity would approach the speed of light instead of being only a small fraction of this velocity. When resting on the earth, however, the opposed impulses against an object balance and cancel one another, so that there remains no final movement relative to the center of the earth. The otherwise unbalanced gravitational momenta of the earth are then fully compensated by the resistances received from the structure of the earth. These forces of opposition are derived ultimately from the usually unrealized gravitational momenta delivered against the opposite sides of the earth.

The object pressing against the earth does not appear to move relatively to it, but it nevertheless oscillates through minute distances during extraordinarily tiny periods. It moves (or at least its separate parts move) back and forth in the intervals between the separated impulses received from opposite directions. Reason tells us what takes place here even though the scientific instruments are too coarse to reveal the facts. Experimental science fails here because it cannot give exact information.

Experience even tends to an erroneous interpretation, for, where the particular condition cannot be observed, the empiricist is inclined to seize upon the average state (which is visible) as though it represented the truth which is invisible. Thus from experience alone one concludes that the apparent state of average quietude is the invisible truth about the parts of the object resting on the earth. Here experience leads to error, for reason calls strongly for constant but imperceptible oscillations. Ordinary observations still proclaim that every piece of wood or steel is inertly motionless; but the more delicate instruments of recent years prove the contrary.

The gross sense-impression interprets with fair accuracy the average state of affairs, but it fails to describe exactly, and even distorts, to some extent, the truth about the whole. We have relied too much upon incomplete experiences and too little upon reasoning in general, and have thus reached conclusions in mechanics which do not apply to the smaller event. If the motion-arc of the swinging pendulum is so tiny that our instruments cannot reveal it, we have been inclined to assert (contrary to fact) that there is no motion, and that the pendulum remains vertical for ever. We then assert that no energy is being displayed, and think we require no explanation of any possible compensations of energy. Why should we attempt to explain phenomena unknown to experiences?

In many cases this denial of motion—that motion which Reason alone calls for—is particularly approved (at least for the time that it can be denied), for, if the motion were admitted in these cases the consumption of real energy could not be explained in terms of mechanics. We thus prefer to deny altogether the unit-motions of the book lying on the desk. And other real motions may perhaps be defined away also as being so small (in time or distance) that they do not express real energy. Still other movements of matter back and forth, which are too gross to be denied, are called "thermal agitations"; and are then, perforce, dismissed as indescribable.

The motions of the book on the desk can no longer be dismissed without explanation. The orthodox point of view can no longer be maintained, for, according to the Newtonian theory itself, the motions of matter cannot be reversed without the consumption of real energy. Energy is being manifested, therefore, in these reversals of the parts of solids, and yet there are no realizable compensations, and no changes in temperatures or average changes in structure to account for the repeated energy-deliveries to the particular volume. This state of affairs puzzling to the mechanists applies not only to the motions of parts in every so-called solid, but also, as we have seen, to the larger movements of the molecules of every confined gas. Particularly in the case of the molecular motions of gases, the doctrine of Conservation is subject to observation and to rigid test, and has been found wanting. No materialistic explanation can be found to fit this phenomenon. The scientist who denies the power of Mind to move matter is in a hopeless quandary. Indeed, the conventional physicist seems to be altogether wrong when he takes the opposite view from that held by Epictetus, who, when asked, "What do you mean by 'nature'?", replied, "I mean, God's will."

To be sure, when sufficient duration is averaged, an object resting on the ground does not display any final measure of unbalanced motion in reference to the centre of the earth. This is only the superficial or generalized appearance of the *average* state of affairs, however, for the object is really the scene of unceasing and violent motions and cancellations of opposed motions. Likewise the gas-balloon seems to rest quietly as a whole, although its parts are pounding back and forth. The many impulses of the parts of the solid weight, however, offset one another so quickly and so perfectly, second by second, that we find it natural (and seemingly reasonable) to assert that no energy is being expressed from the outside against or within this object. We say usually that no work is being done, for even if the tiny movements of the structural parts were perceived, the distances traversed are so small that they would come within the accepted limits of that unit-distance within which energy is not a reality. Indeed, have we not adopted—to meet this very contingency—a convenient definition which recites that no work is being done and no energy displayed unless the movements cover a distance greater than this flexible and undefined unit?

The generalized definitions of our text-books, however unreasonable they may be when applied to the tiny details of their component parts, have nevertheless kept us fairly well satisfied with their general suitability. They were originated to conform with gross, or average, experiences through relatively long periods and with large quantities, and so long as they seem to fill these requirements we are disinclined to doubt their exact and universal validity. These relics of our former ignorance of the particulars, because they conform approximately with our prejudices in favor of the Conservation of energy, and because they have proved fairly practical (and because they have long been printed in weighty books), have taken on a formidable appearance. They seem to us to be almost beyond questioning, and our acceptance of tradition here, and of the incorrect general inferences of general experiences, act as sedatives to scepticism. We incline to accept these old beliefs automatically, just as we accept also, and almost without question, the social structure and conventions of the society in which we are born.

Let us now enlarge our mechanical horizon to take in the whole earth. We shall then find that the forces acting towards and away from it are almost equal from and to every direction. To the extent that they are balanced these forces seem to have no final effect upon the earth's average structure. They serve more to hold its parts together than to move it as a whole. They keep the corpuscles of the elements of earth and sun in constant and uniform motion even while restrained, so that the average temperature of the elements does not materially change from day to day. These balanced motions of parts forward and backward—motions reversed by energies received positively and "absolutely" from the outside—are called "heat-motions"; and yet these energies from the outside, as used in these reversals of motions, are expended as a positive loss to the energy of the outside volume. Nor do they represent any final gain of energy of motion or temperature in the balanced volumes in which the reversed motions take place. Here, too, energy is consumed, evidently, without compensation.

The earth has its own "field" of unbalanced gravitational forces which concentrate directly upon it, and which supply the converging forces acting from every direction upon the centre of the earth's mass, and they do so because they are created by influences emanating *from* the earth's mass. They help only slightly, however, to hold the earth spherically shaped. Indeed, gravity is comparatively a small influence in giving the elements their structure, their densities, their general outlines, and their heat-motions. Among all these forces affecting every earth-element, the unbalanced force of gravity is relatively unimportant.

This book upon my desk, then, is partly impressed by the earth's unbalanced gravitational field, but the reversed and restrained motions of its parts, the thermal activities within its volume, as they are called, are received from forces acting against it equally from every direction. Only the unbalanced part of the total forces acting against its exterior volume tend to press it against the earth (or steadily in any other direction), and no forces are unbalanced in one direction through a relatively long time except those derived from a persistently unbalanced Evolution of matter. Only gravitational forces, therefore (those unbalanced influences due to the unusual density of the earth's mass, and to the unusual densities of other masses outside the earth), affect the elements of the earth in a way that represents steady tendencies to motion. The Evolution of matter causes the relatively dense book steadily to press against the desk with unbalanced energy, and also urges the earth as a whole into a deflecting path around the sun and through the stars.

Of all the forces pressing against the earth only those tend to move it as a whole which are unbalanced with regard to some point outside of its volume, and only the forces of gravity acting towards dense masses exterior to the earth are in this category day after day. Yet these forces of gravity of the earth itself, or of other bodies outside its volume, cannot be interpreted in harmony with Conservation. They represent unbalanced forces just as much as do thermal motions. Gravity is unbalanced steadily because it is the product of the steady dissolution of matter; and thermal motions forward and backward are unbalanced, even in their reversals, for they are the products of the general Power that moves and restrains all matter by constant use of "absolute" force.

Some gravitational influences affecting the earth are spherically balanced with reference to the sun, others to the moon, while still others focus on stellar masses. None of these in the average compresses the earth uniformly, but, rather, all distort its otherwise symmetrical spherical volume. They also create its axial rotation, and urge it into an irregular but approximately repeating orbit about the sun. Some of these unbalanced forces seem to urge the earth towards the sun, while others carry it away. When all the influences of the dissolving pressure-pool have been expressed it is no more possible that the earth should change its mean distance from the sun than that its structure should, under the conditions surrounding it, be compressed into a smaller volume or be expanded into a more diffuse one. Its orbit and its volume are products of the active forces of its environment.

In two respects the earth may be compared to a floating hydrogen-filled balloon. The balloon, like the earth, keeps its constant volume in response to the law of the pressure-pool, and it drifts here and there driven by unbalanced currents. The balloon moves according to the component of all the forces acting against it, and, therefore, it has no tendency to fall to the ground in response to gravity. It subscribes rather to the general principle that whenever, within a certain volume, there is a certain average velocity of parts, the density of mass of this volume cannot exceed a certain amount. This principle applies also to the earth in relation to the sun about which it drifts. If the hydrogen balloon should succumb to the influence of gravity there would no longer be equal energy-manifestations against it from every direction.

The balloon cannot fall to the ground. Gravity is powerless to ''attract'' it closer, for, as we have said, gravity is a resultant of the forces which maintain the general pressure-balances, and it cannot possibly overrule the principle which creates it. Gravity is a secondary or dependent force—a product of an offshoot from a power that is primary. And, just as the balloon defies the gravitational force and floats in the less dense air above the ground, so does the moon maintain its distance from the earth. Its mean distance from the earth cannot be reduced by the earth's ''attraction'' until the time comes when the average of the general force-expression is changed.

We have said that in the various reversals of motions of the parts of the fairly permanent structures of the earth-molecules, the energies from the outside are consumed without those compensations which Conservation calls for. This is the important consideration. Real work—even unbalanced work against the earth-structure—is being done from moment to moment by the book lying on the desk, and yet, in the summation, this energy is being destroyed completely. The weight-force of another equal weight on the opposite side of the earth completely cancels the energy being demonstrated on this side, and no final effects of these accumulations of energy through time are evidenced in appreciable movements of these objects toward or away from the centre of the earth. Except that energy was thus being destroyed, no active Power would be required to re-create motions, but, unless there were this active Power, the matter of the universe would never have moved, and, if ever moving, would dissipate endlessly. Indeed, these energies of gravity are cancelled as completely as two opposed and equal momenta.

A ''pound'' of the earth's gravitational force may or may not do work in reference to the centre of the earth's mass, therefore, in the sense that it accomplishes a finally unbalanced motion of mass, but the energy of the pound is repeatedly being manifested, and work is repeatedly being done by it. The work is real—whether the weight-energy creates recognizable continuing motions in reference to the earth, or whether the forces end in imperceptible oscillations.

Unbalanced gravitational energies are supposed to move the earth about the sun in a deflecting orbit (and also move the book on my desk around with it), but if the duration of a year is considered, no uncompensated energy remains, for the bodies end the year in the situation and with the potential energy of the beginning. Nevertheless, from moment to moment both the earth and the book have responded to unbalanced gravitational energy, and work has been done on them. The final balance does not affect the unit-parts which are unbalanced, and if there is no final balance of work done, and no compensations for the energy displayed in the parts, then energy is indeed destroyed. We maintain, then, that in every case the unbalanced gravitational motion and its energy are real, and are measurable through time as definite amounts—amounts which would in every case accumulate unit by unit as time passed except that they are always cancelled sooner or later without compensations by opposed energies. They are cancelled during a cycle of *more or less* duration. The cycle of the motion of the book on the desk is an incredibly small part of a second, whereas the cycle of the motion of the book about the sun is an entire year; but the principle is the same in both cases. Indeed, except that the book were constantly receiving unbalanced energy, it, as part of the earth, would not move about the sun.

Every expression of gravitational force is real, therefore, and its accomplishment is real also. By its force matter is always given motion through some distance and for some duration. Knowing what we now do about the atomic construction of the pound-weight, and of the earth-elements which resist the forces of these separate parts of the weight by the repeated movements and contacts of small oscillating granules, we cannot deny this motion through distance and this accomplishment. Even those who persist in believing that gravity is continuous, cannot deny that the parts of the book are being moved forward and backward through time and distance by gravity on one side towards the earth and by granular forces in the opposite direction which are transmitted to the book by the earth-structure. Unless one deliberately defines ''work'' to exclude this accomplishment, he must admit that gravity is constantly doing the work on the book, whether it remains on the desk or whether it is falling to the floor.

Now the unbalanced gravitational momenta against an earth-body are repeated at very tiny intervals. If uncompensated, therefore, they would accumulate against a stationary body as a definite amount of stored energy. Almost exactly this quantity of energy is stored in the body when it is falling freely. Only as the body falls very rapidly does the rate of the storing of the gravitational momenta in it diminish perceptibly. And when the body is resting on the ground, the granular forces of gravity are compensated so quickly that we cannot measure the amount that remains uncompensated during that very tiny interval for which it does remain uncompensated.

The falling body, however, which moment after moment receives new charges of uncompensated gravitational force, moves faster and faster. If this increase in velocity continues sufficiently, we say conventionally that energy is being expressed against it; but if the movement is imperceptible we say that energy is absent. There is no difference in unit-principle in the two cases, but, I repeat, we have established our own artificial criterion which denies the use of energy in one case and admits it in the other. Even when an object is falling freely, and receiving one after the other granular ''charges'' of velocity, these increments are so minute that they are not perceived, and we then incline to say, incorrectly also, that the force of gravity is continuous. Thus our generalizations, and our lack of ability to perceive the particular, or unit-event, have induced in us a quite erroneous idea of conditions. That principle which often we introduce as exact scientific knowledge is more than likely composed of parts which are misconceived. Even the formula for the whole is somewhat inexact, and our general theory becomes completely awry.

The gravitational corpuscles are so invisibly tiny that, even though enormously swift, we usually realize their force-expressions only through the noticeable motion of the object which receives their blows. And since an object always moves perceptibly whenever it is released to free response to the gravitational blows, the second-hand weight-force which a freely falling mass can deliver to another object, is taken as a basis of mechanical energy. Visible motion accomplished more or less permanently (*i.e.,* motion which passes through more than some undefined unit-distance) is the test by which we judge whether energy is being expressed in any certain case. A suspended weight may be geared by pulleys so that it will not move another object along a horizontal surface against resistances more than an inch a year, but if this motion is real and detectible, then the weight-force is supposed to do its full quota of work—the same amount of work as if the action were completed in a second. Yet the weight-force of the book resting on the desk is just as real a doer of work as the action of a falling avalanche. There is no fundamental distinction between the two cases, but merely a difference in the amounts of motion and time that intervene before final compensation is accomplished.

The forces of gravity (the accumulating forces of the unbalanced motions of the gravitational corpuscles) must act against an object for a full second of the earth's gravitational field before it will receive a velocity-charge of 32.16 feet a second. The summation of all the accumulated weight-forces delivered to unit-mass in a second equals, therefore, the momentum that this mass will express anywhere when moving at this speed. This amount of stored force can be obtained either by stopping the unit of mass instantly while falling, or by stopping a similar mass during any longer time while moving horizontally. In proportion to the passage of time the unbalanced momenta accumulate in the object falling vertically so that the falling body must be stopped immediately or an additional amount of force will accumulate to be expressed by it; but there will be no such accumulation in the horizontally moving body. The body sliding on a frozen pond will express only one total amount of momentum, or force, however gradually it may be brought to rest. On this account, inertial and gravitational masses are in a constant ratio in respect of the energies delivered by them within a time so short that the influences of the environment do not accumulate; but only the falling body expresses the summation of momenta that we arbitrarily call kinetic energy, for only this weight-body accumulates force through the passage of time. This makes clear-cut distinction between the two situations, but there is no distinction between the two kinds of force, for both are products of mass and velocity, and both are composed of momenta.

Now the unbalanced momenta of the gravitational corpuscles of the moon (because of the moon's smaller mass) deliver only 16.5 per cent. of the earth's gravitational force. The accelerations of gravity of the moon are therefore relatively slower than those of the earth, and more time is consumed there in producing a certain velocity in a mass by the use of weight-force. The smaller value of lunar weight-forces, however, does not affect the principle under discussion, for on the moon, as elsewhere, the inertial mass participating in the momentum formula is almost exactly proportional to the gravitational mass. There, as elsewhere, the force-deliveries are due to momenta, and are granular.

And time also, in so far as it is associated with force-deliveries, must be divided into intervals distinguishable by their different velocities. The corpuscular theory informs us that a falling body moves through a tiny distance at one speed, and that, at the end of this duration and distance, it receives another unit of gravitational acceleration. This new velocity, in turn, is retained until the next gravitational contact is made. If our instruments were sufficiently delicate we could detect the intervals between the blows of the separate gravitational particles. First we could see the object before it started to fall, and then we could observe and measure its motion after receiving the first blow downward, and before the effect of this blow was compensated fully by an upward blow. We could thus identify the final unit of a pound of gravitational force in a certain field, for it would be the unbalanced and uncompensated momentum of a freely falling body of certain mass after receiving the blows both of one corpuscle downward and of one only partly balancing corpuscle upward. And if we knew the number of the smallest bits of matter composing a pound of mass, as well as its velocity after receiving one impulse downward only, we could readily compute the velocity of the impinging particle. Or, again, if we knew all the unit-velocities, we could readily compute the mass of a pound in terms of the number of unit-particles that it contained. The formula of the ballistic pendulum would give us this information. The unit-impulse of the pound of force can be formulated, therefore, only as a momentum.

We have said that the weight-force of a certain mass on the moon represents only 16.5 per cent. of that of the same mass on the earth. If a pound-mass of the earth and a spring-scale were taken to the moon, the spring-scale would display under this mass a force-depression of only 16.5 per cent. of its earthly register, for the cohesive forces giving the spring its ability to resist further compression will be approximately the same on moon and earth. Nevertheless, two equal weights would balance on a lever-scale of the moon just as they do on the earth. The weight-force of a certain inertial mass varies from place to place, but neither the inertial mass nor the cohesion-force is appreciably affected by this change of situation. Mass is one of the two basic realities of the dualistic world, whereas gravitational forces are products of an Evolution which varies with the relative mass-densities of the surrounding volume. Yet we should not assert that the *unit* of gravitational energy is less on the moon than on the earth. It seems rather more probable that the unit of the force induced by Evolution is almost uniform, and that the variations in the summations of gravitational force for a second are due to the difference in the tiny durations that intervene between the expressions of a constant unit of force. The force of lunar gravity is less than that of the earth, on this theory, merely because there are fewer of the gravitational impulses of Evolution on the moon during each second.

We should now begin to understand the significance of the units of conventional mechanics, and the reason for the variations in them for different situations and for different relative velocities. If our later discussion of gravity should reveal that its experienced laws flow directly from the theory of the Evolution of matter, we shall have more confidence in the soundness of our hypothesis. The conventional unit of energy, the pound of weight-force of the earth, is discovered to be merely that certain amount of unbalanced corpuscular momentum which is being expressed towards the earth's centre of Evolution, and against a certain number of other unit-corpuscles collected in a semi-permanent structure on the surface of the earth. This ''pound'' is usually measured in terms of the total gravitational momentum expressed during one second, but it might be divided up into its unit or granular parts. As a matter of practice, however, we determine the pound of energy of a second by measuring the work that a falling object of a pound-mass is able to do against another object during one second. This is our practical working-unit of force, and it is a practical definition of energy if we are interested only in gross experiences with relatively large bodies moving relatively slowly. Nevertheless, if we are ever to understand the fundamental nature of this dissolving world, we must replace our view of gravity with a concept which is sounder philosophically. This new hypothesis, if sound, should explain all the facts of mechanics; it should penetrate these inaccurate and gross formulas and reveal the minuter details. It should, furthermore, so identify the true granules of the mechanical principle that the formulas of physics may be corrected to fit every experience.

Above all, however, this hypothesis which we are here offering, should be welcomed by man, because it founds all life and all experience upon the active presence and power of that Cause which is constantly revealed to us vitally by emotional intuition, and which our faltering and incomplete logic, built upon a superstructure of inadequate knowledge, has thus far been inclined to deny as an influence in mechanics.

CHAPTER XXV

APPROACHING THE CORPUSCULAR THEORY OF GRAVITATION

> In imagination, not in perception, lies the substance of experience, while science and reason are but its chastened and ultimate form.
>
> SANTAYANA.

IN his essay on *Bacon,* Macaulay makes remarks concerning our mathematics and mechanical premises which it might be well to consider.

> Assuming the well-being of the race to be the end of knowledge, he [Bacon] pronounced that mathematical science could claim no higher rank than that of an appendage, or an auxiliary to other sciences. Mathematical science, he says, is the handmaid of natural philosophy; she ought to demean herself as such; and he declares that he cannot conceive by what ill chance it has happened that she presumes to claim precedence over her mistress. He predicts—a prediction which would have made Plato shudder—that as more and more discoveries are made in physics, there will be more and more branches of mixed mathematics.

And again Macaulay renders Bacon's thoughts thus:

> And when a philosophy arose, the object of which was to do on a large scale what the mechanic does on a small scale—to extend the power and to supply the wants of man—the truth of the premises, which logically is a matter altogether unimportant, becomes a matter of the highest importance; and the careless induction with which men of learning had previously been satisfied, gave place, of necessity, to an induction far more accurate and satisfactory.

Bacon was right in his prophecy that changes would be made in mathematics, and also in his criticism of the "careless'' way in which our philosophical premises are chosen. Both quotations are pertinent to the present age, for we still need revisions of formulas, and we should still be very sceptical of our premises—and particularly so when they lead us into inconceivabilities. Now that we have taken a different definition of gravitational forces it will be interesting to see whether our mental confusion is increased or tempered. If the different premise increases our perplexities we should renounce it, but if it makes our working rules more understandable we should view it with favor.

We are basing our theory of gravity upon the assumption that more invisible corpuscles drive a mass towards the earth (and towards other bodies more dense than the average) than away from it. We are trying to follow somewhat the admonitions of Socrates when in the *Phædo* he tells us:

> Would not that man do this most perfectly who approaches each thing, so far as possible, with the reason alone, not introducing sight into his reasoning nor dragging in any of the other senses along with his thinking, but who employs pure, absolute reason in his attempt to search out the pure, absolute essence of things, and who removes himself, so far as possible, from eyes and ears, and, in a word, from his own body, because he feels that its companionship disturbs the soul and hinders it from attaining truth and wisdom? Is not this the man, Simmias, if any one, to attain to the knowledge of reality?

According to the classic belief the earth exhibits a sort of ''suction'' for matter which is proportional to the mass of the object, and which is continuous. According to the corpuscular theory the force is not a ''suction'' but is a disguised ''push''—and is intermittent. In both postulates the earth acts somewhat like a vacuum-cleaner except that the classical ''attractive'' forces are supposed to be expressed without diminution and without source of ''absolute'' energy. According to the corpuscular theory, the dense matter-bodies in a gravitational ''field'' are not ''sucked'' to the earth. No *positive* influence *of* the earth makes them move. In the average the corpuscles would move in these directions if no earth existed. The presence of the earth, like the presence of the vacuum-cleaner, merely prevents the reaction from being equal to the normal action. Within the earth's volume some of the normal energy of motion is negatived, hence the volume displays a negative influence to energy as being generally expressed. It is this excess of "push" towards the earth that we recognize and erroneously describe as "attraction." The velocity of the gravitational corpuscles is not earth-given. Like all inter-world motions it is received from a universal Power. This is the theory. These tiny corpuscles move discontinuously towards the earth from every direction (just as the air-molecules move in every direction in the room) and with an average velocity characteristic of the movements of the corpuscles within the solar spaces.

We perceive here an important contrast between the two theories—a difference, indeed, which requires different mechanical interpretations. In the classical concept not only is the unit of gravitational force regarded as continuous, but it is supposed to be able to add a uniform amount of acceleration to a falling body regardless of how fast this body may be moving towards the earth. Quite different is the corpuscular theory. According to it the particles which by their blows cause the motion towards the earth, have limited velocities, and, therefore, limited abilities to produce accelerations.

The earth is bombarded from all sides by swift and invisible particles. It drifts in their energy-currents impelled by and in balance with them, and is urged by them into its orbit about the sun. Thus driven, thus pressed and compressed, it moves; but as it moves the reality of its own mass, a formation denser than the average of the universe, plays its part, has its effect, and expresses *passively* a real difference. By virtue of the exceptional density of the earth, mechanical transformations take place *unusually* within its volume. Influences are thus manufactured within it which negative some of the reactions normally expected. In this travail, gravitation is born.

If the outgoing energies equalled the incoming there would be no unbalanced impulses towards the earth. Gravitation conclusively informs us, therefore (if we are privileged to interpret all force through the unit definition of momentum), that, whereas there are both receipts and expulsions of swift corpuscles, the energy of the receipts—in so far, at least, as it affects the denser masses—is greater than that of the expulsions. The force of weight measures the lack of balance between these forces against the dense object in question. Yet, very tiny structures (bodies, let us say, as small as the swift-moving and tiny single electrons) may not receive an excess of gravitational force in sufficient amount, or often enough, to be much affected by the gravitational "field" of the earth, even though moving in direct opposition to it.

Mr. John Mills in his book, *Within the Atom,* says that the electrons seem to avoid one another, and do not collide even when the chances seem favourable. However this may be (and we very much doubt that electrons really "avoid" each other at a distance), a body as tiny as an electron can pass farther than a cannon-ball through the earth's gravitational "field."

We do not wish to discuss here the details of the gravitational phenomenon, nor do we wish to say why the gravitational effect is four times as great at half the distance from the centre of the earth, or why it varies also in proportion to mass. We do wish, however, to lay stress upon the principle briefly introduced in earlier pages—namely, that, according to the corpuscular theory of gravitation there is a well-defined limit to the velocity which gravity can impart to an object. Let us trace some of the implications of the theory to see what changes it will make in the Newtonian laws. These classical formulas now contain weight as a uniform and invariable unit of force, a unit that applies to all situations, and therefore incorrectly imply that the accelerations of gravitation will be the same, however, wherever, or whenever applied.

We grant at the outset that the changes in formula made necessary by the corpuscular theory will not normally be very striking. In respect of everyday practices they will be almost negligible. Indeed, the changed results in physics that should be expected from the changes of formulation may not be detectible by our most delicate instruments, for the bullets from our most powerful rifles do not attain even the relatively slow speed of one mile a second. Yet, when we observe X-rays, radium, or electricity, or when we treat with the movements of light-rays in the cosmic reaches, we are dealing with such enormous velocities relative to the earth that the change made in the formula proves most significant. That the rigid Newtonian formula does not apply adequately to the movements within the atom, is attested, among others, by Professor W. L. Bragg, of Victoria University, who writes:

> We cannot explain its [the atom's] mechanism by means of mechanical models, whose properties are those of matter in bulk. There is no justification for extending the same classical laws to these units of matter, and if the attempt is made it leads to paradoxical results. The laws of mechanics may only be proved as the description of the average behaviour of matter on the large scale.
>
> These classical laws build up a complete and logical scheme which has hitherto been found to apply so universally that it requires a great effort of mind to picture any other scheme. At some point they break down when applied to the atomic world. We cannot immediately provide a new logical scheme to replace them; and for a time must be content to be illogical, to work with a mixture of old and new, and to make the best of it. The misfit between the old and new laws has been localized into one great unsolved problem, that of quantum relationship.[1]

The classic laws of Newton, attributing, as they do, unfailing ability to gravitational force to create acceleration in every class of body, however fast it is moving, provide us, according to Professor Bragg, with only a fairly "logical scheme". These formulas apply closely only to bodies moving at speeds, which, relative to the velocity of the gravitational energy-current, are very slow. And the Newtonian concept of a constant gravitational force is neither philosophically sound nor completely accurate. Until recently it was never tested to see how it applied to bodies moving at relatively high speeds. The law has normally been regarded as completely accurate, logical, and thoroughly dependable, but only because most physicists have generalized, have dealt with relatively slow motions, and have considered gross averages rather than particulars. Professor Bragg, in conformity with the opinion of Professor Eddington, says: ''The laws of mechanics may only be proved as the description of the average behaviour of matter on a large scale.'' He might have added, ''on a slow scale.''

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[1] Professor W. L. Bragg, in *Yale Review,* July 1923, pp. 769–770.

Many physicists regard the classical laws as exactly correct for large enough masses moving very slowly, but, according to our corpuscular hypothesis, the Newtonian formulas, because they are based on the concept of a unit of force which acts constantly on a body however fast it may be moving, are never *absolutely* exact. Only when the classical formulas are altered to suit the corpuscular theory will they become exact for general application.

Professor Bragg points out that the physicist is particularly puzzled over the ''quantum relationship'' of atomic radiations. Here for the first time the scientist is confronted with energy-expressions in ''ether'' which are demonstrably granular. Yet, according to his old ideas, these radiations must be continuous. Here, also, the physicist has discovered energies which he cannot explain in terms of Conservation. It is not remarkable, then, that he became confused, and that he is now confessedly illogical. All the old ideas contain error, all of the old generalized formulas are partly unsound, none of the rules representing gravitational force as continuous correctly describes reality. The physicist has been brought to this pass because his premise of a constant measure of gravitational force continuously delivered (as though such a condition were possible) contained error. By introducing a new definition of gravity (and with it a variable unit of discontinuous accelerating force), by admitting that gravitational force produces acceleration in an inverse proportion of some maximum velocity of the object in the direction of the gravitational current, and by recognizing the invisible source of gravity as being exterior to the visible objects which evidence it, we can perhaps modify our formulas, satisfy our reason, and obtain rules better fitting the occasion.

Let us, therefore, consider further this new theory, and learn, if we can, what changes it should make in the classical formulas.

If the space between worlds is filled with corpuscles oscillating at high speed, and if some of these motions towards the earth are not counterbalanced (thus creating unbalanced force-expression towards the earth), and if this gravitational energy-current is partly counteracted by an equally swift but less dense current moving in the opposite direction, then, even though the gravitational current acts for an indefinite time, it cannot drive a dense object ahead of it at its own speed. Likewise, when a piece of paper lies between two air-fans turned against each other it will not be impelled to move with the velocity of the stronger blast. The stronger blast would overwhelm the weaker, to be sure, and would create some measure of motion in its own direction, but the paper would move against the weaker blast at a velocity which would be a compromise of two opposed energy-currents. When the paper has attained a certain speed against the weaker blast it will receive equal momenta from both currents, and when this balance has been attained there will be no further acceleration against the weaker current.

If, therefore, a stream of corpuscles is driving away from the earth, and if this stream helps to counterbalance the stronger gravitational current moving toward the earth, the maximum velocity of a falling body will be less than the average velocity of the gravitational energy-current towards the earth.

If our postulate of conditions is correct, this principle, should hold in respect of all the denser bodies. We are not surprised then when observations inform us that meteors never reach the earth's atmosphere at a velocity approaching the speed of light, and when we learn, too, that most of them arrive with a velocity of about twenty to thirty miles a second. The earth moves about the sun at a velocity of some eighteen and one-half miles a second—about one-ten-thousandth of the speed of light. The astronomers tell us that the great majority of the stars fall into two groups (well mixed, though not in stratified layers) which drift past each other at a velocity of about twenty-five miles a second. By the incorrect formulas of the calculus (see Chapter XVIII), it may be proved that gravitation cannot "pull" a body from an infinite distance to reach the earth at a speed greater than about seven miles a second. Comets, however, reverse their direction and come back to the earth almost solely under the influence of the earth's gravity in a fairly flat trajectory at a speed quite exceeding seven miles a second—thus disproving the mathematics.

The corpuscular theory does not limit gravitational acceleration to a figure which is less than that of common experience, but, in another sense, it does prescribe theoretical limits to velocities. Unlike those who regard gravity as a continuous force which can accelerate to an ever faster speed, we assert that if a fairly dense body should come straight towards the earth at a speed of fifty miles a second probably the contending streams of corpuscles in the earth's fluid environment would retard rather than accelerate the motion. We doubt if the dense object would be in equilibrium with the two contending blasts of particles (towards and away from the earth) if it moved towards the earth faster than perhaps twenty miles a second.

An object under the influence of gravitation seems to resemble a piece of paper between two fans. When moving towards the weaker fan at a speed of say twenty feet a second the paper is in balance with the opposed forces, but if it were deliberately thrown towards the weaker fan at a greater speed (let us say if fifty feet a second) the force of the weaker fan would continue to retard the movement until the velocity again reached twenty feet a second.

This concept is important, and should be considered further. It particularly applies to a body denser than the average density of its environment. It thus refers in one definite way, and through one definite distance, to the piece of paper which is moving under the influence of two opposed blasts of air. In respect of this relatively dense and large body the distance through which it will move before acquiring the balanced velocity is comparatively short; but a much smaller body, such as one of the air-molecules, would not follow the same formulation. Such tiny bodies as single electrons, or the smaller quanta-corpuscles, might pass for greater distances through opposed corpuscular currents without being noticeably affected by them. Indeed, when a tiny electron is moving at a speed of light away from the earth it is possible that it may not be affected by the gravitational current until it has passed so far from the earth's influence that we could no longer observe it, and until some other body influences it more than the earth does.

If, therefore, we consider the theoretical accelerating effect upon a very tiny object of a stream of corpuscles moving towards the earth, we might perhaps be justified in saying that this stream will, in time, give to this object its own average velocity and type of motion, for the object will receive no more retardation from an opposed current than the similar masses which compose the stream. And we can certainly say of an energy-wave moving towards the earth at the speed of light, that the force of the earth's gravitational influence will (to say the least) have no further ability to accelerate it in this direction. We can therefore assert that the classical formula that includes the action of gravity as a constantly accelerating influence must be modified to subscribe to this limiting principle. Certainly, the present formulas are erroneous in that they incorporate weight-force as continuous and as a constant. They are incorrectly constructed on the theory that weight-force can add an acceleration of 32.16 feet during a second to a body falling vertically near the earth's surface regardless of how fast the body happens at the time to be moving towards the earth. Both experience and reason prove the contrary, not only in respect of the transmission of light-energy, but, also, in respect of dense objects.

If the theory that the earth's gravitational influence is delivered by the unbalanced energies of mass-motions at limited speeds is sound, it will particularly affect our mechanical formulas in their relations to bodies moving very swiftly towards the earth. The accelerations of gravity must be definitely limited; the force of gravity must be formulated to stand for the variable unit that it is. Weight-force is less and less effective, as we now perceive, in adding acceleration to a falling object. The effectiveness reduces in the proportion that the velocity of this object approaches some definite maximum speed. At this maximum velocity the force of weight completely loses its energy-potential. The power of gravity to accelerate an object towards the earth diminishes, therefore, in the proportion that it moves towards the earth at this speed.

Thus when a log is tossed from a stationary bank into a swift river, the current will seize it almost as a piece of paper is seized by the wind. It will soon be moving at the speed of the current, but its acceleration will be greater during the first second, and less the next, and progressively less each moment. Not only will less acceleration be added in each unit of time as the log acquires velocity from the current, but the log will never move faster than the current.

In this illustration we have not considered the possibility of an opposed current which might hold the velocity of the log down to a compromise velocity that is less than that of the river. Suppose rain were beating upstream, and therefore driving the log in this direction. We need but mention this opposition of forces to realize that in such cases the floating log will never be accelerated by the river to the velocity of its current.

Now, whereas a similar opposition to gravity doubtless exists in the earth's ''field'' in respect of the heavier masses as they move through comparatively short distances, and while this opposition-current doubtless limits materially the maximum acceleration that gravity can give these masses, we need not complicate our problem here by considering it further. We should notice merely that the denser the inert object is, and the less dense relatively the swift current is, the less acceleration will be given the object from moment to moment. An air-current traveling as fast as a water-current will require much more time and distance than the latter within which to accelerate a relatively heavy body. If the air-current is thin enough, even if moving at a velocity of 100 miles an hour, it might accelerate a piece of wood less than one foot a second during five minutes, whereas water moving at this speed would accelerate the wood to its own velocity almost immediately. We may say, therefore, that the less dense and the swifter the gravitational stream is which during the first second gives a body velocity of 32.16 feet a second, the less reduction will there be in the acceleration from moment to moment, the less noticeable will this progressive diminution of acceleration be, and the farther will the body travel before there will be any certain amount of diminution. In so far as our earth elements are concerned, however, they are composed of hydrogen atoms, and experience has taught us that the gravitational stream accelerates them all in practically uniform fashion.

Assuming, therefore, that no straight-line energy is translated by a fluid medium faster than the velocity of light, the force of gravity cannot make any body move faster than the velocity of light. No amount of weight-force can produce a velocity greater than that which the energy of light can produce by successive impulses. Experience seems to have proved that nothing *does* move faster from one point to another than light-rays. Light-energy, however, as it is translated towards the earth from a star, never appears to move faster than a certain speed. To be sure, as light passes close to the sun on its way from a star it is deflected by the sun's gravitational influence, and in this situation its velocity of translation is somewhat affected, but the *earth does not "attract" light-energy, when moving straight towards itself, faster than the light naturally comes.* The ability of gravity, or weight-force, to cause acceleration disappears, therefore, when an object is very tiny, or when it is moving towards the earth at the speed of light. Experience here coincides with what we should except from the corpuscular theory, but is contrary to the expectations of the classical theory. Some persons, however, willingly accept almost any explanation of the invariant velocity of the translation of light-energy from a star toward the earth rather than subscribe to a corpuscular theory of gravitation.

When weight-force was selected as the unit of energy, the physicists chose that which was not constant (as they imagined) in its ability to cause acceleration. The earth's gravitational attraction is a variable. Its accelerating influence disappears entirely when an object is moving towards the earth at a certain speed. This velocity of motion towards the earth at which the earth's gravitation ceases to cause further acceleration, moreover, seems to be different for different structural densities. The formula for the acceleration which the energy of a pound of force can produce, must, therefore, be modified so as to reach zero-acceleration when the velocity of the object affected by the weight-force has reached a certain maximum speed towards the earth. The corpuscular theory informs us that our mechanical formulas must be made to account for the fact that the effectiveness of weight-energy reduces as the speed of the object approaches this maximum velocity, which, for light, appears to be 186,000 miles a second. Experience teaches us the same lesson.

When a body is moving towards, and therefore conveying potential energy towards, the earth at its maximum velocity (this velocity being less, perhaps, for structural volumes of greater average density, and being the velocity of light, perhaps, only for the least dense formations) the effectiveness of the corpuscular gravitational impulse against it will be zero. These principles may readily be incorporated into the mechanical formula. The amount of weight-energy actually delivered to a falling body (or the amount of work done against a falling body by the striking corpuscles) and the amount of energy delivered in turn by it as a weight-force, may be formulated as a variable quantity by a slight alteration of the formula which now reads: e equals ½mv². Let us change it to read: e equals $\frac{1}{2}\,\frac{(c-v)^4(m)}{c^2}$ where c equals the maximum velocity of the energy-translation of the particular type. The derivation of the formula is given in the footnote.[1]

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[1] Let us assume that a body, m, composed of unit bits of matter, is at rest with regard to the earth, and is being held rigidly against movement by other forces received from the earth's surface. Each of its corpuscles (m, in number) will then be struck n times each second by similar gravitational unit-corpuscles moving at the relative (or effective) speed of c. During t seconds the total gravitational energy expressed against this body—and expressible by it in turn against that which supports it (and, for the moment, we neglect the gravitational force required to keep the surface of the earth compressed)—will equal

We see that a distinction must be made between the energy *being expressed within a certain time* in a certain gravitational "field", and the work being done by that energy during that same time. Here, in gravitational phenomena, the potential kinetic energy of gravitational force and the work that may actually be done by it, becomes separable quantities which must be carefully distinguished. If a sailboat were drifting down a swift stream before the wind, and if the velocity of the stream equalled the velocity of the

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$c\,m\,n\,t$. This will be the weight-force received by the object through time—an amount of energy figurable as momenta. The unit of this force will be the momentum of only one of the average gravitational corpuscles, and will therefore be (c) (1), or c.

If, however, the body should not be at rest in reference to the earth, but should be falling towards the earth through a void, the velocity (v) of its fall at any certain time must be subtracted from the velocity c if one would obtain the effective velocity of the gravitational corpuscles delivering unbalanced force to it. The unit of the gravitational force received by this body will therefore be changed in proportion to the velocity of its fall. The ratio of the force received by the body falling in a void at v speed, to the force received when standing still in reference to the earth, is as $(c - v)$ is to c. When the falling body attains a velocity of c, the unit of gravitational force received by it becomes zero, for it equals $c - c$.

The change of the relative effectiveness of the unit force of gravity when the body falls, however, is not the entire effect, for when a relatively long period of time is considered the falling body, moving in the same direction as the gravitational corpuscules, will receive fewer blows than a body stationary with regard to this current. The total gravitational momenta against the body falling through a void during t seconds is less therefore than $(c - v)$. We have discovered, however, that a body, m, receives gravitational force in proportion to the number of its unit bits of matter—that is, in proportion to m. If a body m falls towards the earth at a speed of v, the number of impulses ('n', when at rest) received by it during each second will reduce from n to $\frac{(c - v)(n)}{c}$. Its total receipt of momenta, therefore, may be formulated as $\frac{(c - v)(c - v)\ (mnt),}{c}$ or as $\frac{(c - v)^2(mnt)}{c}$. Since, however, nt can be expressed as a simple proportion of the elapsed time, t, we may write the formula of momentum as $\frac{(c - v)^2(mnt)}{c}$ or, for unit time, as $\frac{(c - v)^2m}{c}$, or for unit mass as $\frac{(c - v)^2}{c}$.

This amount of force $\frac{(c - v)^2(m)}{c}$, repeated again and again, is the gravitational impulse that causes a falling body, m, to accelerate. The falling body, however, does not fall through a void, as is supposed, but everywhere passes through a field filled with bits of matter which may be regarded in the average as stationary. These bits of matter must be brushed aside in order that the velocity v may be maintained without retardation. Energy must be used, therefore, contrary to the Newtonian axiom, even to maintain a velocity of v in general space. And when a weight rests on the ground, energy is required from moment to moment to hold it down, for the compressed structure of the earth is continually giving it blows upward. When, therefore, a body falls at a uniform velocity of v, or when it lies upon the ground delivering weight-force to the structure underneath it is then receiving (and therefore able to deliver wind blowing that same direction, then, even if all the energy of the universe were incorporated in this wind, this force could not be realized in terms of the motion of the sailboat, or in terms of any force that the boat could deliver to some other object without losing velocity. It is the same with the gravitational breeze. However powerfully the corpuscles of this gale may blow towards the earth, the effective force of it that may be delivered cannot properly be formulated as a constant. None of the kinetic energy may be delivered

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through time) a series of impulses to its environment greater than the necessary merely to maintain a falling velocity of v. Thus, a body falling at v speed—that is, without acceleration—can repeatedly deliver force to another body to which it is attached by ropes and pulleys. Hence it can do work through distance—it can display that which is conventionally called 'energy'. And yet it does this work solely through the momenta received according to the formula $\frac{(c-v)^2m}{c}$—a force, therefore, which is not only in excess of that force required to maintain a speed of v through a void and do work besides, but which can maintain the speed of v and do work besides through a field of resistances. This surplus energy may be summarized. It will not be necessary to go over this summarization a second time. We merely wish to introduce here our different view of the nature of the unit of gravitational force and to trace its effect upon the energy-formula. The unit of the force of gravity, according to the corpuscular theory, varies with the movement of the falling body. It is not a constant *c* for all circumstances, as would be the case if gravitation (as the conventional theory has it) were instantaneous, but is rather to be taken as $\frac{(c-v)^2}{c}$. According to the corpuscular theory, the formula of kinetic energy develops, then, not as $\frac{1}{2}mv^1$, (see pages 667–674 for the reasoning,) but as $\frac{1}{2}\ \frac{(c-v)^4(m)}{c^2}$ When the body is being lifted against gravity, the v of the formula is negative, and the formula becomes, e equals $\frac{1}{2}\ \frac{(c+v)^4(m)}{c^2}$.

In developing the conventional formula, e equals $\frac{1}{2}mv^2$, as we say, no consideration is given to the fact that the forces required to keep a path clear in front of a falling body must be delivered at different points in space. Also new factors must be introduced into the conventional formula (as we have done), because gravity is regarded (incorrectly, we believe) as acting instantaneously,—that is, everywhere at the same time. According to the corpuscular hypothesis, this is not so. The speed of the falling body also affects the frequency of the gravitational blows received by it. The Einstein formula of kinetic energy reads e equals mc^2 divided by the square root of $(1-v^2/c)^2$. The velocity *c*, according to Einstein is the constant speed of light, whereas with us it is not necessarily so. Einstein also introduces time into the Newtonian formula as a variable. Time, according to Einstein as it affects velocity (v), or as velocity affects it, is no longer a constant, but (according to the transformation formula of Lorentz) equals 1 divided by the square root of $\frac{(1-v^2)}{c^2}$. Thus in an indirect manner Einstein takes account of the effect of the relative velocity of the body. He does not, however, incorporate into his formula the effect of the reduced frequency of the gravitational blows when the body is moving. This fact calls for most of the difference between his formula for kinetic energy and the one derived according to the corpuscular theory. The factor *c* is different for different objects.

against a body moving along in front of a current at its own speed. If, therefore, we wish to formulate the gravitational kinetic energy against a body moving towards the earth with a velocity of *c*, it will certainly be a different quantity from the amount of weight-force represented in the conventional formula. We must also understand that weight-force is not delivered by means of a void. These understandings will help us when we later consider the formulas which Professor Einstein has developed to express the kinetic energy of a body moving at speed *c*. We have in the foot-note developed the formula of kinetic energy according to the corpuscular theory as e equals $\frac{1}{2}\,\frac{(c-\mathrm{v})^4(\mathrm{m}),}{c^2}$ where *c* equals the gravitational velocity. The deliverable kinetic energy—energy deliverable without retardation—becomes zero when the body travels towards the earth at the speed of *c*, for then v equals *c*. This signifies that a gravitational current of infinite potential power when moving at the speed of *c* could not deliver energy to a body moving in the same direction at the same speed. Only when a body is relatively at rest, only when the earth's gravitational current is moving against the object at the relative velocity of *c*—that is, only when the current is impinging against a body relatively at rest—does it create within a second the acceleration of 32.16 feet in the elements of the earth. Only when the body is at rest, therefore, is the weight-force of a pound-mass that kinetic energy which it is incorrectly supposed to be always. Only when it starts from rest can a pound of weight produce in another pound-mass within a second an acceleration of 32.16 feet and it can produce this acceleration for the first second only.

Not only does the effectiveness of gravity vanish when the falling mass attains a certain velocity, but when the mass moves towards the earth faster than this, the formula for the energy delivered to it by the gravitational field becomes a minus quantity. That is to say, a body is retarded by the gravitational current when it exceeds a certain velocity towards the earth. Part of its energy of motion is surrendered to the "field." Or we may say that an infinite amount of weight-force when expressed in a certain direction (*expressed,* not *delivered,* in a certain direction) cannot produce a velocity in a moving body greater than this.

This conclusion resembles that of Einstein except that it is reached from a different approach. We do not regard Time as a variable: Empty Space-Time is not warped: Mass is not inconstant. We escape these confusions when we assume that gravitation is the result of the limited and discontinuing delivery of momenta in the form of unbalanced blows from invisible corpuscles. We assume that the gravitational particles move in this unbalanced fashion because there is an Evolution of matter—an Evolution which repeatedly and intermittently creates within the pool of matter (and proportionally more within the denser bodies) that which is the mechanical equivalent of a vacuum. The corpuscular theory is made possible by the theory of Evolution.

The Cause of the dissolving material world is the indirect cause of gravitation. Gravity, to some extent, measures evolution, and of the two evolution is primary and gravity secondary. This tendency of denser matter to move to a certain extent towards denser matter would not take place, however, even in the presence of Evolution, unless a spiritual Power both restrained and moved the matter of the world, and thus created a mechanical pressure-pool of the universe. Within such a pressure-pool, every spiritually created mechanical void becomes a place of note. Every such unusual energy-void must be balanced by an unbalanced motion. We may speak even more generally and say that the two, Gravity the secondary and Evolution the primary, are the measures of a still more primary spiritual accomplishment.

Such a theory of Gravitation is almost suggested by Plato. If Evolution, or significant Change, is postulated to destroy the balance of mechanical forces which Socrates describes in his last discourse, we have then the environment in which unbalanced concentration of substance becomes a reality. Socrates says that where ''one man makes the earth stay below the heavens by putting a vortex about it; and another regards the earth as a flat trough supported on a foundation of air'' yet ''they do not look for the power which *causes things to be placed as it is best for them to be placed* (italics mine), nor do they think it has any divine force.'' And then, he says, ''they give no thought to the good, which must embrace and hold together all things.'' This ''good'' of Socrates is our God, our universal Cause of restrained motion. And we are convinced with Socrates that:

> If the earth is round and in the middle of the heavens it needs neither the air nor any other similar force to keep it from falling, but its own equipoise, and the homogeneous nature of the heavens on all sides, suffice to hold it in place; for a body which is in equipoise and is placed in the centre of something which is homogeneous cannot change its inclination in any direction, but remains always in the same position.

Professor Einstein takes a different view. He regards the universe as a physical mechanism with no detectible mental directioning. He attempts to explain the maximum and constant velocity of light (of that light which is not completely invariant because it *is* ''attracted'' with altered velocity to the sun as it passes, and not ''attracted'' into a faster motion by the earth as it approaches) on a purely mechanical basis. He first assumes—a bold assumption for which we can discover no reasonable support, and based on a hypothesis which may have been adopted chiefly because it seems to give the right answer to some experience—that Time is a variable, that space-time is a constant, and that the time of a moving mass, when taken in relation to the time of some stationary mass, changes in an inverse ratio to the relative velocity. The measure of the change of real Time can be found by taking the time of the stationary body as ''one'', or unity, and by increasing it proportionately so that it will reach infinity when the relative motion reaches the velocity of light, or c.

Obviously, if time (t) varies in proportion to motion, then relative velocity (v) and space (s) are both variables, for both are associated with time in the formula which states that average velocity multiplied by time equals the space traversed by the motion. Only space-time is invariable, and space itself is curved by the presence (at a distance) of an unusual quantity of matter. Through the mathematical development of these premises, Professor Einstein obtains a new formula for the kinetic energy of matter moving through interworld spaces. He says that "the kinetic energy of a material point of mass m is no longer given by the well-known expression $\frac{1}{2}mv^2$, but by the expression mc^2 divided by the square root of $(1-v^2/c^2)$."[1]

In this equation, c is the velocity of light, or the velocity which he believes is the maximum sustained speed of the universe in one direction. The kinetic energy of a body is no longer regarded as a constant amount determinable as one-half the product of the mass and the velocity squared; but it is supposed to be a variable which rapidly *increases* as the velocity approaches c. And Professor Einstein refers to a body's actual kinetic energy, not to the *deliverable* energy. He reaches this formula by assuming that time (t) (at least so far as it affects the velocity (v) of relative motion) varies inversely in a proportion to the relative velocity. He does not consider that which must be true if the corpuscular theory is true—namely, that the frequency of the receipt of gravitational energy is itself less as a body moves faster in the direction that the gravitational force acts. Professor Einstein remarks that this equation of kinetic energy "approaches infinity as the velocity v approaches the velocity of light, c." [2]

If Einstein's premise is sound, and if Time can be a variable, his mathematical equation might be true, and his conclusion might be true also. Then, following this line of thought, because kinetic energy is believed to approach infinity as velocity reaches c, he thinks that this informs us that inertial mass itself may be regarded as a variable. This infinite measure of relative kinetic energy which is attained at velocity c, he asserts, signifies that the inertial mass m of matter is a variable which reaches infinity when velocity reaches c. "The inertial mass of a body," he says, "is not a constant, but varies according to the change in the energy of a body. The inertial mass of a system of bodies can even be regarded as a measure of its energy. The law of the conservation of the mass of a system becomes identical with the law of the conservation of energy, and is only valid provided that the system neither takes up nor sends out energy.''[1]

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[1] Albert Einstein: *The Theory of Relativity* p. 45.

[2] *Ibid.*, p. 45.

All these inconceivabilities, the idea of Time as varying with relative motion, of Space-Time as warped (one way) by the presence of a distant mass of unusual density, of an infinite energy that must be consumed in giving the velocity of light, of an inertial mass that is variable with relative motion, come from the acceptance of an incorrect premise. The physicist is unavoidably involved in irrationalities when he tries to explain the universe on the basis of mechanical determinism; and particularly so when he regards gravity as a continuous source of mechanical power.

The physicist is burdened with unreality by his first step, by the adoption of his first premise. He is led into error by his preconceptions that all motion is mechanically induced, that matter and energy are conserved indefinitely, and that there is no independent spiritual Cause of action. On top of this, the classical physicist (and Einstein also when he regards mass at a distance as curving the surrounding space-time) believes that force-influences can be effective at a distance, and that gravitational force-delivery is constant in the sense that it acts with the same effectiveness against a body whether or not the body is at rest or moving.

The scientist cannot retain these premises without encountering the necessity of reconciling them with contrary happenings. For example, the doctrine that gravity acts at any one spot with the same accelerating force on all bodies at that spot, whether these bodies are moving or relatively at rest, leads to the assumption that velocity can be made infinitely great by gravity—that is to say, that an electron moving towards the earth at the speed of light can be accelerated to a still faster speed by gravity. The facts contradict this assumption, and yet the physicist wishes to retain his rule (so convenient and useful for everyday practices) and to reconcile it with experience through some modifications which he can still describe as harmonious with his Conservation premise. From this necessity have been born some of the rather fantastic ideas that have been suggested by the modern transcendental mathematicians.

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[1] *Ibid.*, p. 47.

Professor Einstein asserts that the kinetic energy of a body approaches infinity as its velocity approaches the speed of light. We should say, on the contrary, that the potential energy of a mass *m* when moving at the speed of light is never greater than its conventional momentum; that its deliverable energy (except when influenced by other bodies in its environment) is always in direct proportion to its relative velocity in respect of the struck object; that tiny masses moving at approximately the speed of light, as many do (electrons in electric currents, X-rays, *beta* radiations from radium, and light-masses themselves that reach us from the sun), deliver amounts of energy which are nowise infinite, but which (provided that they are delivered so quickly that gravitational forces have no time to accumulate) are proportional to the velocities of the bodies. We conclude that not an infinite but a very small amount of energy is required to give a unit-mass the velocity of light in free space. Indeed, whenever a body finds itself in free space it can acquire the velocity of the light-particles coursing through that space in the same fashion that the piece of paper, ''sucked'' from the window by a hurricane can quickly acquire the normal speed of the wind.

We see, therefore, that if one computes kinetic energy from the view-point of the energy theoretically deliverable by the unlimited gravitational force of the old theory, he will require additions to his formula to make it conform to the principle that all the kinetic energy of the universe cannot give a mass a velocity greater than the speed of light. If, however, one has adopted the limited corpuscular theory of gravitation, and then considers, not the energy contained in the gravitational current itself, but that part of the energy which may *actually be delivered* by it to the weight-body, he perceives that all the weight-force (the only kinetic energy which remains unbalanced persistently through time) of the universe could not do more than make the tiniest of masses move at the speed of light. All the energy of his environment—when his energy-tools (his gravity-forces) are properly recognized as the successive accumulations of the momenta of tiny masses, even if concentrated against the tinest of masses, cannot make it move faster in one direction than this speed *c,* for, according to the postulate, no body that produces motion moves at a faster speed, and, also, no one body moves far over an irreversed path.[1] The person, however, who believes in actions at a distance, and who clings to the conventional belief that "attractions" should have an infinite ability to accelerate, requires a different explanation of the definite limits to world-velocity. He first constructs his definition, and then is forced to limit it by complicated and unreal ideas. The corpuscular premise, however, is simple, and seems consistent with other facts. It seems to work. It requires no new definitions and no reinterpretations of old ones.

When the object to be accelerated has attained its maximum speed in the universe, no further unbalanced energy can be delivered against it so as to create additional appreciable acceleration in this direction. This is true even if this same energy-situation would be enormously effective in accelerating slower-moving objects. If, then, we are speaking of kinetic energy in terms of work done through appreciable acceleration, if we are speaking of weight-force in terms of the energy delivered to the weight-body by the gravitational field, there is nothing to be gained by mentioning some enormous potential energy which to be sure, may be acting in a certain direction, but which is acting so slowly that none of it reaches the moving object. Not potential energy, but *deliverable and delivered* energy, is important. If one will make a sailboat move faster before the wind than the hurricane itself, he must be provided with a faster moving energy than the hurricane exhibits. The enormous potential energies of the wind are unavailing if these energies cannot be delivered to the sail as work done.

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[1] When the short end of a lever is moved down the long end moves faster upward, and it seems to the uninitiated that the slow motion produces the faster. The man who presses an orange seed between his thumb and a slippery table top usually reaches the same conclusion. And the ice boat goes faster than the speed of the propelling wind. In none of these cases however does the slower motion create the faster. The motions of parts within the elastic composites which cause the deflected motions are involved here in a way which is not usually recognized.

The hurricane of gravity is just such a restricted force —has just such limits to its capacities.

According to our premise, the corpuscles of gravity have a limited effective velocity, and the force of a weight is like the force of a sailboat driven by a wind-blast with this maximum velocity. However steadily and constantly this gravitational wind blows, however irresistibly it may accumulate through time against a stationary object, however enormous its abilities may be to create acceleration moment after moment in slowly moving matter, this admittedly enormous and repeating energy becomes utterly impotent in terms of the work it can do against a body (or in terms of the energy this body can display as acquired from gravity) so long as this body is moving in empty space in the direction of the current and at approximately its average speed. And, when the object-body (the weight-body, as it were) is moving at the velocity of the current, this body cannot deliver the least amount of force to some other object without itself being retarded. In this respect it is quite different from the book lying there which, hour after hour, delivers pressure to the table underneath, and yet, does not itself move in the average up or down.

He who supposes that gravity can further accelerate an object-body which is moving at any conceivable speed, must explain why these unlimited speeds are not to be discovered anywhere about. He must stretch his imagination to explain how it is that, with forces everywhere which are supposedly able to add unlimited acceleration, no unlimited velocities are discoverable. If we are to follow Einstein along his thorny path, and if we are obliged to arrange a mechanical limit to the capacity of a force which according to the conventional definition is mechanically unlimited, we must accept many ideas which the ordinary man will regard as inconceivable.

The inability of an enormous amount of weight-force to continue to be effective in adding acceleration to a body, does not mean, of course, that an enormous energy is *consumed* in giving a body its maximum velocity in the energy-situation —or that the body is then possessed of an enormous amount of kinetic energy of its own. If weight-force *could be delivered* effectively to a unit-mass with the velocity of *c,* then a very tiny amount of energy indeed would suffice to give this mass this velocity. Or, if one could avail himself of a mass moving at the speed of ten *c* as a striker, the velocity of *c* could be exceeded quickly and easily, and with little use of energy. And if gravity were an unlimited force, as is is generally supposed to be, comparatively little weight-force would be consumed in giving a small mass a velocity much greater than *c.* The belief in limited gravitational force seems more reasonable, therefore, than the idea that gravity has unlimited ability to accelerate. This new view seems especially valid now that we perceive that when we regard gravity as continuous, and as unceasingly effective, we are forced immediately to curb this theoretical ability to accelerate, and are obliged to reduce the powers of gravity to the maximum of practices by adding limiting factors to the equations in which it appears. We are compelled to formulate gravitation in a mathematical equation that would be exactly the same as it (for moderate velocities, at least) even if gravitational force was (as we now claim) delivered by intermittent blows given at minute intervals.

If, moreover, one is to prove that an infinite energy is really to be delivered to an object in terms of work done against it in order to give it the tremendous velocity of *c,* as the Relativity theory stipulates, he must prove that a mass when moving at the velocity of *c* itself possesses infinite energy which it will deliver to other bodies as it is brought to rest by them. Indeed, if an object which is supposedly possessed of infinite potential energy when it is moving at the speed of *c,* fails to deliver this energy when resisted and brought to rest, the fact of this failure must be explained away or it will disprove the theory that it has ever really possessed this infinite energy. We are familiar with the fact that light-rays, X-rays, and electric masses moving at approximately the speed of light, do not deliver infinite energy when they collide. Rather, they deliver the conventional amounts of momenta for the masses and velocities. That is to say, experience proves (whatever our theory may be as to the amount of potential energy delivered to, and therefore possessed by, a moving body at the velocity of light) that an energy-wave in a material fluid when moving at this speed is quite unable to deliver more than the normal impulse. The Einstein theory does not here correspond with the facts, for we perceive no employment of infinite energy in creating the velocity of light, and we observe no delivery of infinite energy through the blow of a mass moving at this speed.

Experience seems to disprove the hypothesis that weight-force can accelerate a moving body as quickly as a stationary one. And we must not explain this discrepancy between theory and fact by asserting that Time is to be regarded as a variable, or that inertial mass itself is a variable, but we should admit that we have taken an unreal and supposedly continuous "pull" for our unit of gravitational forces instead of a real and limited "push." One's perplexities will vanish if he but regards "attractions" as unrealized momenta accumulating unit by unit through time, and deliverable only as contacts, and if he then realizes that the effectiveness of gravity (or of the weight-force in the formulas), as expressed in an object, reduces in the same fashion that all overtaking momenta are bound to do—namely, that the delivered momenta will be less in the proportion that the object speeds faster and faster in front of the series of separately overtaking masses.

Accepting, then, the corpuscular theory, hoping to explain its details satisfactorily, and hoping to find that it subscribes as closely as it should—and no closer—to the inverse square law of the conventional theory, we deny that the property known as inertial mass increases as velocity increases, and that the kinetic energy and inertial mass of a body moving at the speed of light are infinitely great. These concepts are possible only for him who conceives that gravity should attract the fastest body ever faster, and who tries to explain away the inability of gravity to accomplish this result. If one hits upon the idea that Time is a variable as an explanation of the invariant velocity of light, he will obtain the Einstein formulas and come to the Einstein conclusions. This, however, does not make the Einstein conclusions correct. Apparently they are based upon an incorrect assumption. If the assumption is changed, the conclusions will change into others more reasonable and less provocative.

Now these theories have their branches, which, if the hypothesis is sound, should be traced; but I shall not attempt to trace them here. Thus, if this corpuscular theory of gravity is sound, when a body moves faster and faster in opposition to the gravitational stream, the retarding force against it will increase, and the effectiveness of the driving-power which is accelerating the body against gravity should rapidly diminish. We should have the right to suppose, therefore, that the acceleration would finally cease altogether. It is quite in accord with the concept already brought up in the case of the piece of paper blown by a stronger fan against the current of a weaker one, except that gravity now represents the blast of the weaker fan. Acceleration against gravity will soon cease, because the effectiveness of gravity increases relatively as the relative velocity against it increases, whereas the accelerating moment of the stronger current will diminish, in turn, as the body moves faster in front of it.[1]

There is another interesting development of the theory. We have supposed that energy was not required to maintain the velocity of a body moving horizontally *in vacuo* on a frictionless surface. This would be true, theoretically, of course, only if the vacuum were really empty of matter-particles. Yet the very balance of the earth in the streams of corpuscles impinging invisibly against it from every side, proves to us that there is no perfect vacuum extended in space, and that even though all the air were withdrawn from a glass tube, the inside space would still be permeated with corpuscles moving in every direction. The gravitational corpuscles themselves permeate the vacuum-tube, and resist horizontal motion. Force must be used to push a mass through these currents sidewise, and for this reason energy is required to move a body on a frictionless and horizontal surface even *in an air-vacuo.* This energy may not be readily measurable at the relatively slow velocities with which we normally treat, but the principle becomes important when the velocities approach the speed of light. We may assume, indeed, that when a very tiny body has attained the speed of light in a vacuum-tube, an energy equalling the energy of its weight-force when at rest will be required, not to accelerate it further, but to maintain its motion at a constant velocity through and against the stream of the gravitational current alone. While these ideas differ from the conventional ones, they may some day be proved correct by the delicate instruments that doubtless will be developed. Let us now proceed to trace the laws of gravitation according to the corpuscular and evolutionary hypotheses thus far suggested.

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[1] The maximum velocity attainable by an electron is approximately the speed of light, or Einstein's c. If, however, the particle delivering the energy-quanta of radiant light-energy has less volume-density than an electron, we should then suppose that the maximum velocity of such radiant energy would exceed the maximum velocity of an electron moving through corresponding space. In our formula for kinetic energy, therefore, the velocity of c is the velocity of light (as it is in Einstein's theory), but only for light-movements themselves, or for movements of objects with corresponding volume-densities. When our kinetic energy formula is applied to a single hydrogen atom, for example, the factor c in it becomes a velocity very much less than the speed of light. Every object, according to the corpuscular theory, will have its own maximum speed (its own c) for transmitting energy in straight lines, and this maximum velocity will depend upon its own volume-density.

CHAPTER XXVI

PREPARING THE GROUND FOR A CORPUSCULAR THEORY OF GRAVITATION

> Anyone will renovate his science who will steadily look after the regular phenomena. And when the science is renewed, its new formulas often have more of the voice of the exceptions in them than of what was supposed to be the rules.
>
> WILLIAM JAMES.

BEFORE considering the subjects new to this chapter, it might be well to review briefly some of our conclusions.

All forces are delivered, we assert, by the contacts of corpuscles, and when two smallest bits of matter collide part of the ''charge'' of motion passes instantly: The struck object cannot move faster than the series of strikers in the average move: Every acceleration is compounded of separate impulses, and between these impulses there is no increase of velocity: Motion is destructible—but only by the opposition of a power of the kind which created it: It may be created or destroyed without mechanical compensations, for motion is not a permanent attribute of matter. It may be shed—just as a wire may lose its electric charge: Indeed, a certain ''charge'' of motion is retained by an object only for a short time, for oppositions to motion are frequent. A universal, imponderable, and purposeful Power exterior to matter endows it with motions: Matter is moved back and forth within limited bounds, often within limited formations of the same parts, and during these cycles it is repeatedly brought into collisions in which the motion-attribute is lost: And in some of these collisions matter is even transformed into non-matter: Everywhere within the limited universe the parts of the composite formations,.as well as particular objects moving as wholes, transmit energy in straight lines up to the points of contacts and with a speed that is less as the density is greater: A general equilibrium of energies is thus maintained; and an almost uniform energy-delivery is received through average time by every relatively large cross-section.

If an object should be thrown into the universe from the outside, it would soon be moving in such fashion that the energy-deliveries against it would average the same from all directions: Inert substance moves, never of its own volition, but only because and when it is moved: the gift of motion is bestowed upon matter in order that a mental purpose may be accomplished: Thus matter and mind are brought into an Evolution: The transmutation of matter into mind is mentally planned: It is being slowly accomplished by an unmechanically founded motion: Thus, ''absolute'' change is created: These significant alterations of averages affect both mental and material realms: The Evolution of matter takes place un-uniformly in space: On one side only of the edge of the physical universe are there mechanical motions, collisions, and Evolutions: The densities of physical structures also vary from place to place: For these reasons, whereas energy-expression is fairly uniform, it is not thus with the Evolution of matter: Unbalanced movements in space are necessary to adjust the uneven destructions of material inertias: Let us follow these assumptions to some of their conclusions.

The earth floats in the pool of the universe like a log in a medium of uniformly pressing water-molecules. Her changing velocities and directions are due to the blows of the corpuscles composing the surrounding fluid. Between blows the earth moves in straight lines with a velocity inherited from earlier contacts, but each second she receives impulses from many directions which change her velocity and direction. The effects of the last blows are constantly being compounded with the velocities, directions, and magnitudes of forces inherited from earlier impulses. The change in the direction of the earth's movement is regulated to some extent by her own inertia, but except that new impulses were constantly being received, the earth would move out of the solar system and into an indefinite emptiness. She does move, however, about the sun in a majestic sweep, and our theory informs us that her slightly oval orbit represents the composite effect of all the myriads of blows against her. And because these blows are intermittent the orbit is a succession of extremely short straight sides.

Most of the impulses against the earth are opposed in kind and almost balanced. They therefore tend to annul one another within the dense mass of the earth. So far as they are balanced they serve to keep the earth's structure compressed; but so far as they are unbalanced they tend to drive the earth before them. And yet, because there is always an excess of impulse from one direction, and because the direction of the forces changes in different parts of the orbit, the earth is driven into a curve about the sun at a speed of about nineteen miles a second. Although seemingly free and untrammelled, the path and structure of the earth signify that each instant a balance with myriads of exterior energy-influences is being perfected. Indeed, so long as the energy-current about her is what it is she cannot move otherwise. Her course is as much a product of exterior force as that of a floating barrel in the suck of Niagara.

This is our statement: Can the facts be explained according to this hypothesis? Or, must we accept the conventional view and assume that the earth is deflected by ''attractions'' acting between sun and earth, and that her structure is being maintained in cohesive balance by equally inconceivable attractions of parts which do not touch one another except occasionally, and which, immediately after the contacts, ignore the power of the supposed attraction by separating immediately? Let us see which theory deserves our support.

Energy shoots from the sun in enormous amounts. Invisibly small particles radiate with immense force; and their energies, whether coming long distances as projectiles, or whether transmitted as energy-waves from piece to piece of the diffuse material fluid composing the intervening medium, tend to drive the earth away into space. Aware of this outbound energy from the sun we realize that unless another force of like kind shoved the earth repeatedly towards the sun she could not maintain her average orbit. Unless she received the batterings of innumerable corpuscles moving at tremendous speeds towards the sun she could not hold her curving path. Impelled on all sides by opposed energies, the earth floats in balanced equilibrium. In order to maintain this harmonious balance with her energy-environment she is obliged to move each year first 93,000,000 miles on one side of the sun, and then approximately this distance on the other.

The force which acts to deflect the earth's immense mass into a re-tracing path is supposed by most physicists to come from the sun, and to act through an entirely empty space. Attraction is supposed to be an attribute of the sun even though it acts here at the earth. Nor is the sun usually supposed to lose any of its own qualities, energies, or masses by expressing this attraction. The supply of attractive force is regarded as inexhaustible, the ability to move matter is not supposed to be weakened by use, the well of power, though always being emptied, is deemed to remain forever full.

The doctrine of mechanical Conservation is virtually abandoned when this inexhaustible source of mechanical power is assumed, but this fact is disregarded. Yet it is necessary that the following questions should be answered: What loses energy that the earth shall be ''pulled'' ceaselessly towards the sun? And what loses energy also that the ''cohesion'' of a wire rope composed of the separated particles shall support the Brooklyn bridge through the years? Is ''attraction'' really created from nothingness? Or from pure whim?

Even if the force of attraction were real, it is impossible to explain why it should be created in an exact inverse proportion to the square of the extension of that amount of void which happens to lie between two bodies. Indeed, according to the philosophical view, the theory of an ''attraction'' as a form of mechanical energy is untenable. Common sense makes us deny it as unreal. Yet the science of physics needs either the law of gravity or its approximate equivalent. But the philosopher also demands some reasonable sort of explanation of cohesions, tensions, and capillary actions. What, then, shall we do? Probably we must use a theory of "attraction" until a more worthy substitute can be developed. This is sensible; but we should hold to it tentatively with the frank admission that we have attained nothing more real than a working formula. We should admit that the concept is irrational, and that it is adopted only for the moment. It is to be surrendered as soon as a better explanation is offered. It is only a name temporarily given to a result which will later be otherwise explained. Yet many of the Newtonian physicists scoffed at any attempt to substitute another theory for this inconceivable one.

The English scientist, Huxley, expressed a finer and broader opinion than most. In his lecture on *The Progress of Science,* he said that a force delivered by contacts was a "*vera causa* of which, to all appearance, we have constant experience". Then, when referring to attractive or repulsive "force", he said that it was "a metaphysical entity which is physically inconceivable. Newton expressly repudiated the notion of the existence of attractive forces in the sense in which the term is ordinarily understood; and he refused to put forward any hypothesis as to the physical cause of the so-called 'attraction of gravitation'." Huxley remarked that "As a general rule, his [Newton's] successors have been content to accept the doctrine of attractive and repulsive forces, without troubling themselves about the philosophical difficulties which it involves." Referring to the vulnerable gravitational theory of LeSage, who attempted to "show that the phenomena of attraction and repulsion are susceptible of explanation by his hypothesis of bombardment of ultramundane particles", Huxley said that this theory "Whether tenable or not, has the great merit of being an attempt to get rid of the dual conception of the causes of motion which has hitherto prevailed."

What a broad-minded, far-seeing, and encouraging word is this from Huxley! How few physicists even of the present day admit the unreality of their theories of attractions and repulsions! How few investigate a new hypothesis that may explain that which the old theory merely hides in dusty mystery bags!

LeSage could not support his corpuscular theory of gravitation because he omitted from it that which might afford unbalanced force. He did not realize the basic unreality of the Conservation doctrine, hence his ideas contained inconsistencies and intelligibilities. Nor was Descartes' theory of vortices based upon the right premise. Huxley anticipated the development of a more perfect corpuscular theory when he said that it was "safe to look forward to the time when the conception of attractive and repulsive forces, having served its purpose as a useful piece of scientific scaffolding, will be replaced by the deduction of the phenomena known as attraction and repulsion, from the general laws of motion."

It seems necessary now to abandon the idea that planetary motions are caused by "attractions" at a distance, or by space-time curved at a distance. We become convinced of this when we realize the nature of the current of invisibly small particles in the spaces between worlds, and when we interpret the significance, the power, and the effect of this stream of moving bodies. The believers in the old type of gravitation cannot account for the influences of the energy-currents in the particles known to be between worlds. Indeed, many of these faithful clingers to old traditions fail to realize that the classic theory is no longer tenable. They believe that, except for "attractions", the planets would continue to move with unretarded velocity in straight-lines. This hypothesis, however, must be surrendered as soon as it is admitted that the space between planets and sun is not a void, but is filled with corpuscles possessing mass and velocity of the conventional kind. Many of the modern physicists even incline to deny that a corpuscular theory of gravitation might be possible because they have no explanation of the earth's orbital motion in terms of it. Thus Mr. A. d'Abro, in *The Evolution of Scientific Thought,* writes of LeSage's Corpuscular theory: "When furthermore we realize that the earth moves around the sun without slowing down in any perceptible way, as though its motion encountered no friction, we are compelled to conclude that the density of the gas formed by the corpuscles cannot surpass a certain limit''. (p. 428) He believes the earth would become white-hot from the impact of these corpuscles. And, he continues: ''The same difficulty would arise were we to seek to save the hypothesis by substituting for the impact of material corpuscles the pressure of invisible electromagnetic radiations (possibly of the nature of Millikan's rays).''

We have referred many times to the universal energy-equilibrium. An energy-balance is a necessary postulate for any association of moving bodies. Mechanical energy cannot remain motionless alongside of an energy void. As soon, however, as we posit that, in the average, there is everywhere a uniform amount of mechanical energy-expression, we must at once admit that bodies of appreciable mass do move back and forth in the spaces between worlds. Nor is this density of mass in the volumes between worlds a negligible factor. These different conclusions negative the belief that the almost constant mean lineal velocity of the earth is inherited from indefinite ages. We now know too much, we claim, about the conditions prevailing between worlds to believe longer in the old theory of gravitation. The earth moves through a space filled with masses that cannot be brushed aside except by the constant use of a large amount of ''absolute'' energy. The earth does not whirl forever with velocities inherited from the day of her creation as a planet; but rather she floats in harmony with an invisible current of unbalanced energy which is itself revolving about the vortex of the sun. The earth does not become white-hot from the impact of these corpuscles, for the motion of the earth is due to the unbalanced energies of these very particles.

It is not necessary that we directly experience the unbalanced energy-current between worlds, for reason tells us that matter and its energy reside there in certain definite amounts. Yet some knowledge has been acquired by scientific men. Professor Langley has estimated that the sun emits enough heat to warm 2,200,000,000 worlds like our own at 93,000,000 miles from the sun. And a heat-stream delivers a blow similar to that of a cannon ball, hence no earth can cut through such a stream without the use of energy. It is known, too, that electrons and alpha particles, both with mass and inertia, shoot from the radioactive elements away from the earth, and they must deliver unbalanced energy into the space between worlds. Some thirty-eight radio-active elements have already been discovered, hence the inter-world spaces must be filled with moving masses.

Not only can a ray of heat revolve a wheel like a gust of air, but light, too, can deliver a real blow. Professor George Ellery Hale tells us of the pressure exerted by a beam of light:

> Nichols and Hull devised and built in 1901 a radiometer for this purpose [to test the pressure of light] which left no doubt as to its reality or magnitude. Subsequent theoretical investigations by Schwarzschild showed that for particles of dust a few millionths of an inch in diameter, and of the density of water, the repulsive force of the sun's radiation is about ten times as great as its gravitational attraction. As the finest dust is always repelled by the stars, whatever their distance, it must continue towards the most remote depths of space.[1]

Day by day the discoveries of science prove that light represents the radiation through space of energy of the usual sort. For this reason the spaces between worlds must be fitted with a fluid possessing the usual inertia. It is impossible that ether-waves or empty voids should deliver the mechanical blows of light.

Professor Ernest O. Lawrence and Mr. J. W. Beams, both of Yale University, writing in the *Scientific American*[2] concerning the nature of light, say that "The collision of light with metal surfaces causes the ejection of electrons in a way that is quite incompatible with the theory that light is a wave motion of the ether." Then they remark that "As time has progressed, many additional phenomena concerned with the interaction of light and matter have been discovered which are impossible of understanding on the wave theory and which have compelled scientists to revert to the conception of light [the corpuscular concept] which was in Newton's mind centuries ago." And again, "Light beams contain certain amounts of energy which are exact multiples of a definite smallest amount. . . . Thus we have atomicity of light as well as atomicity of matter and electricity." To extend this idea of atomicity so that it will include all forms of energy, we must assume only that "attractions" are granular and composed of quanta-units. The idea that light is atomic, and that it delivers the usual discontinuous granules of energy that we should expect from the blows of tiny corpuscles, certainly carries the strong inference that a light-beam represents the movement of corpuscles of matter with the usual inertia—a theory which will be expanded in chapter XXIX.

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[1] George Ellery Hale: *The Depths of the Universe,* p. 57.
[2] April, 1928.

Professor Hale says the dust-particles are bombarded by light-energy with a force that sends them into the depths of space. The nebulas are supposed to consist of this light-repulsed cosmic dust. How, then, is it possible that the earth can proceed unretarded for aeons of time through even this current of light which has an energy sufficient to overcome the inertia of heavy dust?

Certainly, the scientists have discovered much that contradicts their old theories of light and gravitation! They have supposed that ether has neither mass nor inertia yet they state that waves of it repel dust-particles by striking them. They suppose, too, that the earth has only her original velocity to account for her repeating motion about the sun, yet it is known, not only that she constantly curves (thus constantly absorbing energy), but that she passes through an unending current of heat and light and cosmic dust possessed of the unusual inertia. Professor Charles Lane Poor estimates that from "ten to twenty million meteors enter the earth's atmosphere each day." And the presence of the cosmic "rays" of great penetrating power that have recently been discovered by Professor Millikan, affords additional proof that the spaces between worlds are full of impending matter.

The slowing-down effect of all these resistances to inherited motion must be enormous. Indeed it must be capable of retarding the motion of the earth appreciably in a short time. Notwithstanding all this, it is assumed that the earth proceeds serenely through this hurly-burly without experiencing important retardations during countless centuries. Or, it is assumed that the space between world's is empty. Such are the exigencies confronting the scientific opinion. Yet once it is admitted that the heat and light-energy emitted by the sun tend to drive the earth away into space, it must be admitted also that an energy more potent than the theoretical "attraction" restrains the earth from this radial motion.

Let us not accept the many unrealities following from the hypothesis of attraction! Let us believe that the earth revolves about the sun in an energy-swirl of conventional masses sufficient to drive the earth ahead of it, and sufficiently powerful to maintain her motion and her orbit even were there no force of "attraction." Let us try to explain the planetary orbits in these terms. Let us see whether this hypothesis will interpret the phenomena of the tides, the single rotation of the moon during one revolution about the earth, the constant velocity of light-energy translation from stars to earth, and the fact that there is no drift of light-energy in the imagined ether with regard to the earth. If we grant enough potency to the blows from the surrounding current we may be able to explain the earth's orbit without attributing reality to the "attraction" of the sun. Indeed we have come to just such a surrender of our old concept of the cause of planetary orbits. We are convinced that the constant mean velocity of the earth in her repeated orbit cannot result from an inherited motion; and we are sure also that her average path cannot possibly be that which might be induced by a force of attraction—which certainly should have no ability to display "absolute" energy.

Faraday almost suggested the idea that there was a field of conventional matter in the realms between worlds, but he described the space as being a "field of unbalanced force" rather than a field of exceedingly diffuse matter in exceedingly swift oscillatory motion. Faraday suggested the idea that matter and its energy were identical, and physicists have been inclined to hold to this opinion largely because they have been unable otherwise to explain events in terms of Conservation. In his autobiography, Professor Michael Pupin describes Faraday's theory to us as follows:

> Faraday's tensions, as I found them nearly forty years ago, disclosed in his *Experimental Researches in Electricity,* went even so far as to suggest that matter itself consists of centers of force with lines of force proceeding from these centers in every direction to infinite distances; and where these lines of force are there is the body; in other words, every material body, like every electrical and every magnetic charge, extends to infinity by means of its lines of force; and hence all material bodies are in contact, explicitly defying the existence of ether. No mortal man ever suggested a bolder suggestion! And yet to-day we know that a conception regarding the structure of matter very similar to that first conceived by Faraday is rapidly gaining universal recognition, not merely as a new metaphysical speculation but as the logical and inexorable demand of experiment.[1]

Faraday conceived that matter spreads itself everywhere through immaterial lines of force that virtually form a continuum. Matter is known by the energy it emits, yet we cannot see how there can be more energy-expression in one part of this continuum than another. Faraday implied that energy (and, therefore, matter also) could be found in uniform amounts throughout all the volumes of the universe. R. A. Gregory, in writing of Clerk-Maxwell, the pupil and interpreter of Faraday, says that:

> Faraday in his mind's eye saw lines of force traversing all space, whereas the mathematicians saw centres of force attracting at a distance; Faraday sought the seat of phenomena in real actions going on in the medium; they are satisfied that they found it in a power of action at a distance impressed on the electric fluids.[2]

According to Gregory, Faraday sought the seat of phenomena in the ''real action'' of the object itself—the action given out by the object to the medium enveloping it—and not in a "power of action at a distance impressed on the electric fluid." Was Faraday right, however, in suggesting that perhaps there was an imponderable magnetic field which could itself, and without the presence and inertia of matter, be a seat of phenomena? And can matter be an original source of energy? Can it emit from itself into other spaces an immaterial field of power, a "field" of energy which has the ability to move other matter-bodies without physical contacts? We see no particular reason or basis for this belief. Nevertheless Faraday was right in abandoning the incomprehensible idea of forces acting at a distance—that is, in spaces where no general "field" of energy could be identified. He was also justified in surrendering the concept of an ether-filler for space, for this assumption is as unreal as the concept of an attraction at a distance. It is inconceivable that an imponderable medium should develop electromagnetic vibrations, or lines of force, or mechanical strains, or should cause matter to move. It is equally inconceivable, however, that there should be "lines of force" in spaces where there is no matter.

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[1] Michael Pupin: *From Immigrant to Inventor,* pp. 228–9.

[2] R. A. Gregory: *Discovery of the Spirit and Service of Science,* p. 294.

The confusion brought about by arbitrarily assuming, at least for certain occasions, that matter and the potential energy of its motion are the same, has persisted and spread. It has recently been further popularized in the theories of Professor Einstein. Thus a modern English writer, Mr. J. W. N. Sullivan, remarks about the discovered mass of electricity: "Here we are led to a very startling and novel conception. We have supposed that only matter has mass; electricity has been classed as an 'imponderable', that is, as something possessing no mass. But this notion cannot be maintained."[1] He says that electric currents not only have momentum, but they do not attain maximum strength instantly, and the force persists for a time after the current is cut off. Electricity has inertia, and an electric charge adds mass to an object.

Everything goes to prove that an electric "field" is virtually a "field" filled with inert matter. Sir J. J. Thomson proved that more energy was required to give an electrified sphere a certain velocity than was needed when it was discharged of electricity. Following up this fact, Mr. Sullivan, when considering the electron by itself, and when asking how much the mass of an electron is increased by an electric charge, says: ''We reach the startling conclusion that the *whole* of the mass of an electron is to be attributed to its electric charge.''[1] He then remarks: ''We shall see that all atoms may be conceived as built up out of electrons, and since electrons consist of nothing but electricity, we see that we reach an electric theory of matter, where matter is held to consist of nothing but electric charges, and to have no mass except the mass that results from these charges.''[2]

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[1] J. W. N. Sullivan: *Atoms and Electrons*, p. 60.

Yet we are not obliged to accept the view that matter consists of nothing but imponderable charges of electric energy. There are other possibilities. Why reach a conclusion that prevents one from distinguishing between electric energy and an ''electrified'' composite mass? Why be dogmatic in the opinion that ''matter'' and its ''electric charge'' are synonymous terms, that matter cannot be anything but electricity; and that, therefore, mass is really imponderable, as electric energy is assumed to be? Why not admit rather that the electron is an inert mass, and that, when moving freely at its characteristic inter-atomic speed, its momentum is what we know as electric energy? We may admit, too, that the mass of the electron is the unit of mass which is added by the receipt of a unit electric charge. It may also be true that all bodies are composed of electrons, but it does not follow from this that all colliding bodies deliver only the energy-effect known as electricity. Indeed, electricity, or the energy-delivery known conventionally as electricity (the mass of the electric charge not usually being recognized because it is so minute and because it remains so transiently in the ''charged'' structure), is not expressed unless the colliding electrons are moving at a speed of about 186,000 miles a second. Yet, many large cohesive bodies, objects that may be composed of electrons, move slowly, and probably the electrons composing them also move relatively slowly within them. The energy-expressions of these large bodies are not called ''electricity'', for they are energies of the usual kind, energies in which the inertia and mass of matter is visibly recognized.

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[1] *Ibid.*, p. 61.
[2] *Ibid.*, pp. 61–2.

It seems apparent, too, that bodies even smaller than electrons give blows different from electric energy—such, for example, as the blows delivered by light-and-heat-energies. In general, the ordinary mass-blow is to be distinguished from an impulse of electricity by the fact that the moving particles of electricity are invisibly small, and are moving at great speeds, and are delivering the energy principally by virtue of speed; whereas the delivery of the blow of an ordinary object is realized chiefly because a relative bulky mass arrives at relatively slow speed. In both cases energy-delivery is due to more than the material attribute of inertia.

Energy is a compound—inert matter plus motion—and the electron, wherever it may be, is a piece (or structure) of matter of conventional kind, possessing inertia, having no motion of its own structure as a whole, and being, therefore, without finally unbalanced energy of its own to be expressed exterior to itself. Being ordinary matter, the electron can give varying energy-effects, however, when its structure as a whole is charged with those different amounts of motion—those that are to be expected in the energy-pool as average structural densities vary. Energy-deliveries may be notable either for their immense speeds combined with small mass, or for their huge visible bulks combined with relatively slow velocity; but only that delivery with extreme velocity and invisible mass is known as ''electricity''.

The greatest velocity is naturally found only in combination with relatively diffuse formations—in situations, that is, where the parts are so tiny and so invisible that it is not always easy to be sure that both mass and motion have been delivered. We conclude, nevertheless, that an energy-delivery must always signify the delivery of both mass and motion. An electric charge, therefore, must always be a mass-charge, but a mass-charge need not be an electric charge.

Electric and potentially magnetic ''fields of force'' should therefore be defined as volumes in which invisibly tiny particles are transferring energy at a straight-line speed of about 186,000 miles a second. According to such a definition electromagnetic "fields", as Faraday suggested, doubtless extend everywhere—even through space usually regarded as empty. Indeed, the acceptance of the belief in electromagnetic "fields" pervading all space, adds weight to the conclusion, independently reached, that the spaces between worlds are filled with a diffuse material fluid which cannot be continuously penetrated by a planet moving with constant velocity except by the repeated use of "absolute" force. With this additional assurance that the conditions in the volumes between worlds are as we have assumed, let us return now to our consideration of the earth as she moves through this space filled with light-and-heat-energies, meteors, cosmic dust, and electromagnetic "lines of force".

Newton said that if a piece of matter is alone in space, and if it is given only one "charge" of motion, it will move forever thereafter in a straight line. However, matter does not for long exist alone. Innumerable corpuscles, as we now realize, oscillate in every volume of the restrained physical universe. They vibrate back and forth through limited distances like tennis balls passing back and forth over the net from player to player. But this energy-equilibrium is not our most important consideration here. A transformation of matter takes place, and, as the inertia of matter disappears, the mechanical equilibrium of the pool is destroyed, and unbalanced movements follow. And because the evolution of matter is unusually frequent in the volumes of the greatest density, these unbalanced movements tend unusually towards the centers of the denser objects. For this reason the orbital energy-currents revolve around the denser centers of mass The universe seems to us to be virtually a fluid volume with many whirlpools, in which planets, like logs, revolve around some particular vortex of unusual disappearance. A part of this space is filled with invisible but proportionately more energetic corpuscles, and in it, the earth, one of the denser patches, floats, moving in conformity with the surrounding energy-deliveries just as the log drifts in conformity with the whirl of the pool. The compressed earth floats in this energy-filled space; but all the time the corpuscles composing the elements of the earth are rebounding from blows received from the exterior stream, and everywhere, when gross averages alone are considered, there is a perfect balancing of forces.

Each blow against the earth instantly changes her direction and velocity. The earth possesses no inherent centrifugal force, and she neither gives nor receives attractions or repulsions through emptiness. The earth revolves about the sun, but merely because, when thus floating in the current of swirling and impinging corpuscles, she receives equal impulses from every side. She responds to all the blows expressed against her, an enormous number each second of time, but she is such a tremendous mass that the impulse of a single particle makes no appreciable change in her direction. Her course, nevertheless, is altered by each blow, and each second she is deflected in the average .119 inches from the straight-line path. Yet, after a year of deflecting blows, the earth moves from almost the same point relative to the solar system and in the same direction of the beginning. Taken as a total cycle-effect, the real and separate energy-impulses creating the orbit may be looked at in one way as if self-cancelling and non-existent.

The earth is like an enormous ballistic pendulum struck by an indefinite number of invisibly tiny bullets moving with immense velocities in many directions. Her average motion is such that her energy of motion represents the force which permits her to subscribe to the principle of universal energy-equilibrium. Each part of her cycle represents unbalanced energy (just as do the oscillations of the book on the table), but her cycle as a whole represents a zero of effect—that is, it manifests that complete balance as brought about by opposed and repeated forces, all doing work, a balance, however, which can be obtained only by movement through appreciable time and space. The earth could not, as Mr. d'Abro says, move around the sun through the swirling stream of striking particles from inherited energy. Her orbit represents a succession of surrenders to the mechanical necessities of her environment. She resembles a log in a whirl-pool, which only if it revolves with the current will be struck by equal blows of the water-molecules from all directions.

After the earth has attained the average velocity of the current in which she floats, she could not, if then isolated, be brought to rest except by blows equal and opposite to those which gave her the original motion. Nevertheless, since she revolves in approximately repeating orbits, and since her bulk is so large and dense that it cannot be penetrated, she must move also with the average speed (when compounded in this one direction) of the unbalanced energy-currents surrounding her.

The classic theory of orbital motion was originated by Sir Isaac Newton, who, with the skepticism to which we have already referred, was the first to prove that the force called gravitation, when acting with a power varying inversely as the square of the distance would account for the average paths of the different planets. Newton, however, did not know that the spaces between earth and sun were filled with particles which the earth must brush aside without retardation if she were to move under the influence of gravitation alone. Had he realized the inertias of these masses between worlds, and the radial energies also of the light-and-heat-emissions from the sun, he could not have conceived that the gravitational pull of the sun alone could account for the repeating planetary orbits. As easily might a log revolve unretarded in a pool of motionless water when "attracted" only by the vortex. When once it is granted that water fills the space between the log and its vortex, then no force-principle other than the energy of the moving water itself is required to account for the motion of the log. A radial force could not possibly overcome the sidewise resistance of the water.

It follows, therefore, that now the presence of the current between worlds is realized, it must be acknowledged that this current causes *all* the planetary motions.

No place remains for the influence of an imaginary force operating radially from the vortex—and no place, either, for inherited and unchanged lineal velocities. If, however, the spaces between worlds were empty, as the former scientists conceived (although at the same time they assumed that there was an unaffecting, indetectible, and yet all-pervading ether between material bodies), the gravitational force of the sun, even then, could not account either for the oval path of the earth or for her changing orbital velocities. The Newtonian hypothesis of orbital movements is proved false at the moment it is discovered that the spaces between worlds are not empty, but contain these myriads of particles with the mass and inertia of matter heretofore defined. *In fact, if we grant enough potency to the blows from the surrounding current, we may abandon all ideas of gravitational forces, and yet be left with a complete explanation of the earth's orbit.* Certainly, no scientist would claim that a combination-influence, that of an inter-world current combined with a force of ''attraction'', can explain the orbits. Therefore, since the presence of the current is completely proved philosophically by the reasonableness of the theory of energy-equilibrium, and partly proved also by experience, the idea that there is an additional ''attractive'' force must be abandoned.

In *Astronomy,* written by Simon Newcomb and Edward S. Holden, the corpuscular theory of gravitation advanced by LeSage is briefly mentioned, but it is dismissed with this statement: ''This and all theories of the kind are subject to the fatal objection of proposing complicated systems to account for the most simple and elementary facts.''[1] These scientists supposed that gravitation adequately explained the facts. In a later sentence, however, the authors of *Astronomy* soften their criticism of the corpuscular theory by admitting that: ''If, indeed, such [corpuscular] systems were otherwise known to exist, and if it could be shown that they really would produce the effect of gravitation, they would be entitled to reception.''

Many a log has swirled in a whirlpool in a path similar to that taken by the earth about the sun and yet no one has supposed that the water-vortex ''attracted'' the log! Why? Because we are aware of the water in the pool and perceive that its average motion corresponds with the motion of the log. The current about the log in the whirlpool is opaquely visible.

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[1] Simon Newcomb and Edward S. Holden, *Astronomy,* p. 150.

From the outside we can dip our fingers into its flow and become conscious of the impact and drag of the striking water-molecules. We can feel both the power and the inertia of the stream. We obtain from it physical sensations, and therefore awareness, not only because the water is comparatively dense and sluggish, but because we ourselves are standing relatively motionless outside of it. If the water were as invisible as the particles of the current between worlds, however, and as haphazard in unit effect, and, therefore, as imperceptible to our organs of sensations, if we were ourselves drifting with the flow so that no power of it against our bodies would be unbalanced, we would not realize its presence. If nothing were visible to us between log and its vortex, if we were drifting with the log and unable to feel the unbalanced rush of the current against ourselves, we would likely enough fail to conceive the true cause of the motion. Indeed, were the water altogether invisible, then, since only balanced, and one at a time imperceptible, pressures come against the log from every side, a quite ingenious person would be needed to develop the erroneous explanation that the log moved as the resultant of two forces forever existing—one, the original velocity of the log when thrown into the pool, and the second, a mysterious force of "attraction" acting at a distance from the visible vortex to the log through empty space. And another great mind would be required to formulate the law of this unreal force—of the average routine of this principle supposed to be continuously acting. When the current of water was realized as an important character of the pool, however, this ingenious preliminary hypothesis of "attraction" would be found superfluous and unreal. The law of the whirlpool, and the law of the impulses of particles within such a pool of evaporating matter, might then be seized as an all-sufficient explanation of the log's orbit.

And so in the universal pool. If a restraining Cause holds matter within bounds, and moves matter everywhere within fields of matter expressing equal energies until an Evolution is accomplished, then a new concept is necessary. We must also surrender the unreasonable concept that the motions of electrons in atomic structures do not affect their environment.

The analogy of the evaporating pool, with its uniform pressures, and with its motions about the vortex, seems to fill our need. And the concept of the ''push'' may readily be substituted for the ''pull''. This substitution even satisfies us better, for the ''push'' alone corresponds with our definition of matter and its inertia. Equipped with this different hypothesis we may discover that there is no need of imagining new types of matter and energy as means of explaining the phenomena of planetary orbits, of gravitational weight, of tides, and the like. In the case of the water, however, the vortex is quite visible into which the nearest particles of water rush. The water finally disappears radially into a centre of disappearance. There is no such general diminution of matter in the universe, the physicists assert, and therefore, there is no explanation for a current rushing into a vortex of disappearance.

Certainly if there is such a vortex, it cannot be seen. Indeed, it has been asserted for centuries that the amount of matter and its energy in the universe are never changed. This idea of the changelessness in the amount of potential and active energy as mechanically defined (the basis of mechanics) has always received the support of the physicists, and most scientists still believe in it. Let us ask them, however, if they believe in an Evolution by which change takes place in one direction only while average motion does not lessen? Certainly, if such an Evolution does affect matter, the idea of the Conservation of matter and its energy must be dismissed. And if the Evolution of matter itself is admitted, then the vortex formation becomes a reasonable and even necessary concept.

Professor Whitehead touches upon these points:

> A thorough-going evolutionary philosophy is inconsistent with materialism. The aboriginal stuff, or material, from which a materialistic philosophy starts, is incapable of evolution. This material is itself the ultimate substance. Evolution, on the materialistic theory, is reduced to the rôle of being another word for the de-

> scription of the changes in the external relations between portions of matter. There is nothing to evolve, because one set of external relations is as good as any other set of external relations. There can merely be change purposeless and unprogressive.[1]

And again: "We cannot look to nature for the justification of our belief in any such law as the law of gravitation. In other words, the order of nature cannot be justified by mere observation of nature."[2] In other equally suggestive passages he hints at the universal pool of balanced energies. Unless there were such an energy-pool, how could change be spread from one place to another with the dependable uniformity to which he refers? And yet the idea of the restrained energy-pool is quite contradictory to Conservation, and inconsistent with our present-day explanations of orbits, whether of planets about the sun or of electrons about atomic nuclei.

Professor Whitehead speaks of the recent introduction of four new ideas into science, one of which was made necessary by the electromagnetic theory of light-radiations—namely, "that a field of *physical* activity pervades all space, even where there is an apparent vacuum."[3] The idea of an ether is accepted and then rejected in this concept of a continuous volume of something which is homogeneously solid, and yet able to undulate. How, without a belief in the spread of uniform energy to every point where sensation appears, could we think that "our experience, dim and fragmentary as it is, yet sounds the utmost depths of reality," or that "Faith in reason is the trust that the ultimate natures of things lie together in a harmony which excludes mere arbitrariness"?

We have the "faith that at the base of things we shall not find mere arbitrary mystery."[4] Because matter thus exchanges its energy, and its power to give sensations, it results that "In our sense-experience we know away from and beyond our own personality."[5] And, for the same reason, "the world disclosed in sense-perception is a common world, transcending the individual recipient."

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[1] A. N. Whitehead: *Science and the Modern World*, p. 157.
[2] *Ibid.*, p. 75.
[3] *Ibid.*, p. 143. (Italics mine)
[4] *Ibid.*, p. 27.
[5] *Ibid.*, p. 130

It is true also that "In a certain sense, everything is everywhere at all times. For every location involves an aspect of itself in every other location. Thus every spatio-temporal standpoint mirrors the world."

But this would not be true except for the average uniformity of energy-delivery throughout. This uniformity makes possible the delivery of a delicate radio-impulse thousands of miles away. Likewise, if a bird's wing strikes the surface of a perfectly quiet and balanced lake, the effect can be detected by a delicate instrument on the farthest shore. Except for this balanced equilibrium throughout physical realms, would it be true that "this functioning of the body in one place, exhibits for your cognizance an aspect of the distant environment, fading away into the general knowledge that there are things beyond"? And, "if this cognizance conveys knowledge of a transcendent world, it must be because the event which is the bodily life unifies in itself aspects of the universe." [1] How else should there be disclosed in ourselves "these same general principles of reality, which we dimly discern as stretching away into regions beyond our explicit powers of discernment"? [2]

Poetry, says Professor Whitehead, tells the same story: "Value is an element which permeates through and through the poetic view of nature", and he defines his "value" as the intrinsic value of an event. He also refers to "the fixed scientific cosmology, which presupposes the ultimate fact of an irreducible brute matter, or material, spread throughout space in a flux of configuration." He then defines "scientific materialism" as the assumption that such a senseless material "just does what it does do, following a fixed routine imposed by external relations which do not spring from the nature of its being." [3] He proposes, however, to challenge this view as being "unsuited to the scientific situation."

Now we agree that the idea of "irreducible brute matter"

[1] *Ibid.*, p. 133.
[2] *Ibid.*, p. 135.
[3] *Ibid.*, p. 25.

as presupposed by science is entirely unsuitable to the situation as we find it. We believe that matter is reduced, or evolved, but we believe also that a routine is imposed upon the volumes containing matter by powers which are at the time external to the material bits. It would seem, even, that the ideas of science and religion can blend in that which we propose. Science might easily accept the reasonable and also religious view, for science can be explained, we think, in terms of a spiritual cause of physical phenomena. However, science has thus far refused to make these concessions. The result, therefore, is as Professor Whitehead describes it: "The stable foundation of physics have broken up; . . . The old foundations of scientific thought are becoming unintelligible. Time, space, matter, material, ether, electricity, mechanism, organism, configuration, structure, pattern, function, all require interpretation. What is the sense of talking about a mechanical explanation when you do not know what you mean by mechanics?"[1]

The explanations advanced in this work are founded upon its hypothetical definitions. Beginning with these premises, the conclusions have followed, and, it is hoped, with reasonableness. We now come to another link in the development of the theory. We believe that there is an evolutionary tendency to the concentration of the denser objects into a vortex, and that this accounts for the orbit of the earth. We believe, too, that the mechanical conditions and laws are similar to those of a spherical (or, possibly, cylindrical) and fluid whirlpool of evaporation. According to our view, the force of a "push" alone is ever expressed. We must now determine whether the unbalanced "push" of matter developing in such a pool will act with a force which is inversely proportional to the square of the distance between the denser bodies.

The universe, we say, is cohesive with a general, reversing, and therefore, "absolute" force, and the "cohesion" of every stone, of every atom, is due to this restrictive power exerted radially inward (in the average) from the bounds of matter. Except for these blows the parts of our floating earth would erupt like trench bombs, and all her elements would become instantaneously radioactive. Without explanation of the force of restraint, Sir James Jeans made the same assertion concerning atomic structures. Except for the will of a creative Cause, the parts of the universe would not move; and now that they do move, except for the reversing forces, the universe would not remain long with limited volume. Local cohesions grow out of the principle of general cohesion. Except that the universe were restricted as a whole, no structure of moving parts would remain in one consistently dependable formation even for a second. And yet we must deny that particles impinge against the earth from every direction if we are to believe that the earth is held together entirely by the aid of some mysterious force passing through empty space from particle to particle. So, applying our different thought, we realize that neither the earth's orbit nor her cohesions can be explained through the classic theory of ''attractions''.

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[1] *Ibid.*, p. 24.

Every six months the orbital direction of the earth is reversed. Her earlier potential energy of motion in one direction is cancelled twice each year. A directional energy is exhibited in the latter half of the cycle which is opposed to the earlier force-expression. How can this be? Whence comes this force which destroys an energy and replaces it by its opposite? The potential energy of the earth when moving in any of its directions is a real and tremendous quantity. How can this energy be annulled? And how is a new energy of motion created with a reversed potentiality? Newton's law of motion states that ''change of motion is proportional to the acting force, and takes place in the direction of the straight line in which the force acts.'' According to classical principles, therefore, straight-line-motion cannot be deflected repeatedly without the repeated use of real energy. What, then, is the source of this ''absolute'' energy? How can it be explained according to Newtonian principles?

If an invisible and unfelt wind blew always towards an island in the sea impelling to its shore every floating object; if every boat were compelled by this unrealized air-current to move towards this one shore, persons lacking sufficient knowledge would naturally assume that the island exercised a potent "attractive" force for floating matter. They would likely believe this even though they were forced to acknowledge that the "attraction" was not philosophically conceivable. When, however, the unperceived and unrealized current of air was finally revealed to experience, the concept of a force mysteriously attracting would become unnecessary. Observers would then agree that here no inconceivable "pulls" operated through nothingness, but that invisible air-molecules drove the floating bodies ahead of them towards the island, and that the blows of these invisible particles caused the concentration.

Grant us, then, first, the finite pool-formation with an exterior force restraining the matter-particles by returning them constantly from the outer bounds towards the centre of the pool; secondly, an energy-equilibrium throughout such a pool which, when disturbed, is being restored as rapidly as the motions of the adjacent matter permit; thirdly; a repeated Evolution and disappearance of some of the inertia-property of matter; and finally, a more rapid Evolution in the denser volumes,—followed promptly (according to the general principle of pressure-equilibrium) by equalizing motions which, to begin with at least, focus towards the centres of the denser masses—grant us that these principles pertain to the earth as well as to the log in its pool and the orbital motions of the planets should follow as a matter of course. The unreal theory that the inherited velocity of the earth is never lessened, increased, nor compensated, will then no longer be required, and we need no longer attempt to understand forces at a distance. We need but conceive that planetary motions are caused by the unbalanced energies of motions, of the whirling and invisible corpuscles of the fluid in which the planets float.

The finite universe has nothing physical outside of itself, and a universe pictured as being similar to a perfectly balanced and self-oscillating pendulum, is a universe unimportant and uninteresting. It contains no possibility of being worthy of investigation. It is dead and impotent. Lacking the ferment of change, and of "absolute" power to change, there remains to it no vitality. What importance or interest can a universe hold that lacks the principle which promotes Change? And how can a pendulum oscillate with reversed motions unless there is somewhere a principle capable of overruling pure mechanism? But, if there is such a principle, might it not create an Evolution in which mind might be created out of matter?

The evolution of Spencer, when viewed as a matter of pure physics,—the creation of a negative mechanical condition here while a positive is being created there, a process in one direction which is soon to be altered inexplicably into its own equal reverse,—is irrational. It is meaningless as a process while it occurs, and the cause of the reversal of the movement is both mysterious and inconceivable. What compels matter as a whole to come together with greater complexity and then to dissipate with a lessening of complexity? There is obviously a limit to the concentration of matter, but there is no spatial limit to dissipation. The reversal of a general dissipation into a process of concentration without the use of a general exterior force, moreover, requires more explanation than Spencer gave. A repulsion cannot change itself at will into an attraction unless the power of "will" is admitted and postulated as an active and potent character.

It seems essential, indeed, that significant evolutionary Change in both matter and mind should be acknowledged. It appears to be the very parent of being. And, after Evolution has once been accepted in a universal and "absolute" sense, we find ourselves provided with an understandable theory of the local concentrating tendencies of certain types of material structures. We need no longer suppose that the island towards which the invisible wind blows is able to attract the sail boat with an inconceivable "pull". Let us return, then, to our thesis, admitting that the conditions of the universe may be as we have described them, and let us consider further the paths of the planets in the light of this theory.

We have misconceived the nature of the interworld spaces chiefly because the single particles moving there (conveying energy through gross distances perhaps with the velocity of light), have delivered such tiny separate energies to us that we have been unable to see, hear, touch, smell, or in any way sense their separate existences. We have therefore supposed that the moving parts of earth-bodies were held together by mysterious attractive forces. With little ground for the belief, we have assumed that the spaces between worlds were empty; and we have incorrectly supposed that the cohesions which result in more or less permanent matter-structures in the denser parts of the universe might be explained as the products of attractive and repulsive forces acting at a distance. We have disregarded the pool-like formation of the universe as a whole, and we have failed to note the positive but restrained motions and concentrating blows within it. We have merely formulated certain average energy-routines.

Both experience and reason now inform us that, between worlds, in the invisible realms where our ordinary senses cannot reach or detect matter, there is this potent "field" of moving corpuscles, and that, just as the separately invisible water-particles offer stubborn resistance to the passage of a steamer, these inter-world particles must be pushed to one side with ever-presented energy if world-bodies are to pass through them. The earth must either cut through this current with self-contained power, or else she must merely float or drift carried along by the movement of the stream. As we can perceive no evidence of boilers and engines, or sources of "absolute" force, or any will or purpose in the inert matter of the earth, we shall, unlike many of the early philosophers, refuse to endow her with arbitrary power, or with planned and independent ability to act. As we feel no gale of particles blowing against her brow as she rushes along her orbit, we conclude that the earth has none of the independent glory of the ocean liner, but that she is merely an inert, drifting mass, floating like a log, and obeying as an obedient physical servant the delivered power of the mental and universal Cause. Like the smallest of the inert bodies, her mass is responsive to, and in equilibrium with, the mechanical energies of the moving masses in her environment. She is submissive to the fundamental principle of inertia. She is merely a large and dense aggregation of dead substance, and has no appreciable powers reaching beyond those given to matter of our definition.

Balbus, the friend of Cicero, in his discourse on *The Nature of the Gods,* claimed otherwise. He said: "Now, we see that there is nothing in being that is not a part of the universe; and as there are sense and reason in the parts of it, there must therefore be these qualities. And these, too, in a more energetic and powerful degree, in that part in which the predominant quality of the world is found. The world, therefore, must necessarily be possessed of wisdom; and that element which embraces all things, must excel in perfection of reason. The world, therefore, is a God, and the whole power of the world is contained in that divine element."[1]

Plato regarded the earth as a self-sufficient and central body entirely out of communication with the rest of the universe. The stars and planets were merely ornaments in the sky, or perhaps Gods living above and thinking of, and working with, the earth. Some of these earlier philosophers, perceiving that Reason had developed in human beings springing from this earth, argued that the earth herself must be the parent of Reason. Indeed, if this were so, the earth as a whole must needs possess even higher reason than that of man.

Plato contended that there were two sorts of motion, one innate and one external—one spontaneously derived from within and the other caused from without. He regarded the former as more divine, and he attributed to the mind alone the power of self-motion. He therefore concluded properly that the first principle of motion must come from a mental source. He concluded incorrectly, however, that "since all motion is derived from the heat of the world, and that heat is not moved by the effect of any external impulse, but of its own accord, it must necessarily be a mind, from whence it follows that the world is animated." Heat is an effect, not a first cause.

We, of to-day, with a different knowledge of facts, define our physical world differently. We attribute to her no free-will, and no ability to think. To be sure Reason springs from her in the sense that mentally endowed organisms call the earth their mother. As Cicero said, the earth contains the possibility of being the parent of appreciable wisdom, but this does not mean that her rocks and rivers and air and fire and heat are themselves wise. These elements, on the contrary, represent dumb, and apparently unresponsive substance! They are parts of that realm which, so far as we can perceive, is quite insensible. Inorganic matter is practically dead. Indeed, its degree of deadness distinguishes it from the actively mental. From outside the earth comes that intelligent force which, by its powers, causes arbitrary motions, arbitrary rearrangements of particles, and which thus creates mentally endowed organisms out of a parent-earth, that, as a world of matter, is quite unmental. The early philosophers believed that the earth was majestically supreme and uniquely all-important. Little did these thinkers dream that the earth in her universe might be compared to a speck of sawdust floating in a mighty medley of energy-oceans.

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[1] Cicero, *The Nature of the Gods,* par. XI.

Nor does the fact that attractive forces respond to mathematical formulation prove that a theory of attraction is sound. Have we not now learned why the formulas associating force and time give fairly accurate results even though founded on incorrect theory, and even though the formula is inaccurate when referred to the blow of the unit of matter? And have we not also disclosed the fundamental inaccuracy of the practical working rule for kinetic energy? The theory of gravitation is equally misconceived.

We assume first that there *is* an "attraction at a distance". We then derive formulas describing the effect of this imagined continuous force, and these formulas prove fairly dependable for every-day experiences. The formulas, nevertheless, are incorrectly founded. Though fairly practical, they are fundamentally unsound in that they have been evolved without reference to certain facts of created restraint, of Evolution, and of necessary discontinuity. They will not begin to satisfy our philosophic concepts; and they illustrate their incorrectness when we attempt to apply them to the unit event. In the light of our present-day knowledge of the "field" of matter between worlds, moreover, they have become grossly unreal. The theory of "attraction" is evidently incorrect; and although it has been temporarily useful as a generality, the vice of unreality has been associated with its virtues of practicability. It does not describe nor aid in the formulation of facts as they are; and it gives us irrational conceptions of our physical surroundings.

The laws which Kepler and Newton propounded, would, we say, have been as true of the "push" as of the "pull". Of course the conditions surrounding the "push" must be properly conceived if the impulse of it is to be the exact opposite of a certain kind of "pull". What, then, must this world-environment be if its "push" is to correspond to the inverse square law of attractions—so far as the law does apply? To discover this, is our problem. If our philosophical concepts are correct, the mechanical formulas based upon them should apply perfectly even to the unit event—to situations, that is, where the inverse square law of gravity, conceived as a continuous attraction, does not apply.

We therefore assert that the earth moves about the sun in the midst of a swirling energy-current compounded of the blows of invisibly small particles. These blows, or unbalanced energies, or "lines of force",—or lines of masses, as you may prefer to call them,—keep the earth moving, first closer to the vortex and then farther away, faster one moment and slower another. As she moves she is bombarded by the unbalanced oscillations of bits of matter as derived from unbalanced energy-emanations from the sun. These tend to drive her away like cosmic dust; while other corpuscles strike from other directions. She herself reflects and then emits some of this energy received, and she spouts forth unbalanced energy from her own structure. Her equilibrium is maintained by her changes in speed, curves, and radioactivities. Her orbit represents the attainment of the balance of her own energy-volume with the forces which, by impinging in unbalanced fashion, make her move.

Not all the striking particles, however, urge the earth around the sun, for if this were the case her orbit would either be circular or spiral—and not elliptical. I shall attempt to prove that the orbits of planets correspond with the laws of whirlpools within fluid volumes having more than one vortex of evaporation.

If the extension of the sidereal universe is finite, the solar system itself must move about some external focal point in a sidereal orbit. The final balance of the unbalanced blows is attained, therefore, in harmony also with the influence of that larger whirlpool of evolution in which the solar system itself moves. At times the earth moves in opposition to this sidereal stream, then she moves sidewise to it, and then, again, her motion is in the same direction. As the earth proceeds she is shoved by an energy-current moving as if (for the time in question) in one general direction. The dense earth is urged, then, by two diffuse energy-currents (composed, however, of material corpuscles too diffuse to interfere much with each other), and under this double influence her orbit becomes egg-shaped. Two forces may give a circular motion, but three or more forces are required to give a repeating *oval* orbit.

We can view the solar system—consisting as it does of a thousand or more dense bodies of appreciable size—as though the sun were unable to move, while a sidewise current acts constantly in one direction upon the planets as they, in turn, revolve in a different energy-stream converging upon the sun. This concept must be clearly understood, for, otherwise, we should agree with the astronomers that if a steady force acted in one direction upon the revolving planets, and upon the sun as well, it would have no effect on their orbits about the sun. A whirlpool in a river will not be affected by the fact that the stream at the time is flowing steadily in one direction, but, nevertheless, one whirlpool in a river will be affected by another whirlpool which acts on the same water-molecules, and if one orbit is very small and the other extremely large, the influence of the larger orbit will virtually be that of a sidewise force acting upon the revolving current of the smaller.

The point where the earth comes closest to the sun is the perihelion, and the farthest point is the aphelion. As the earth moves from aphelion to perihelion she is being forced constantly closer to the sun by the influence of the sidereal stream; but when the perihelion is passed, and as the earth moves toward the aphelion, this universal influence forces her away from the sun. Nevertheless, we may continue to affirm in general terms that the distance of the earth from the sun is always such that each instant the composite effect of all the blows—both of those energies spiralling towards the vortex of the sun, and of those carrying her in the large sidereal path—is sufficient to deflect her into that path which she does follow. For an earth with a certain volume, density, and average velocity, there is only one possible mean orbital distance, hence, if the earth were placed slightly farther away she would come back to her present path, and if she were shoved slightly closer to the sun she would move out again.

According to the classic gravitational theory, those who regard the universe as finite must presuppose that there is a general centre of gravitational influence outside the solar system which should pull the planets toward some very distant point. The astronomers, however, do not believe that this general force of gravitation causes the eccentricity of the planetary orbits, for they can prove by the calculus that the repeating oval orbit can be accounted for by the sun's attraction alone. They do not admit that their mathematics is faulty, yet just here its error leads them into an erroneous interpretation of causes, and into an erroneous philosophy.

When a log rotating in a whirlpool is blown steadily in one direction by a gentle surface breeze, it no longer remains in equilibrium with the water-pressures of that pool, but moves in a path made oval by the force of the breeze acting in one direction only. If this breeze were invisible and unrealized, the repeating egg-shaped orbit would be a mystery. The eccentricity would depend upon the relative strength of wind and water, upon the density of the log, and upon the angle of the breeze to the plane of the surface of the pool. The distance of the log from the vortex would also influence the eccentricity. If, however, the breeze blew perpendicularly upon the surface of the water,—from above instead of sidewise,—the log would be pressed farther down into the water; but the general contour of its orbit would then be circular.

The eccentricities of the orbits of the different planets, therefore, if they are oval because a similar sidewise breeze blows them, should depend somewhat upon the angle at which the plane of the planetary orbit intersected the plane of the breeze. If, however, the direction of the breeze itself gradually rotated, the axes of the orbit would rotate harmoniously, and we might then observe the phenomenon known as the rotation of the perihelion which is discovered in the orbits of the planets as the solar system revolves in its separate sidereal orbit. If the direction of the breeze did not change, the ellipse would not rotate around its perihelion point, and probably the planet would finally take an orbit in a plane perpendicular to the direction of the breeze.

The astronomers, as we have said, suppose that the water of the pool and its revolving log will both be blown sidewise an equal amount by a sidewise breeze. They cannot imagine that the water in the pool should be less affected by the wind than the log, and they believe this because they do not observe the important parts that the general principle of energy-equilibrium should play here. If the pool of water as a whole should continue to be blown to one side by the breeze, a tremendous energy-void would be left behind—something that cannot occur in a uniform energy-pool. The eccentricity of the log's orbit however is quite another matter. The log can revolve off-centre without any permanent breach in the general equilibrium of forces. It does not continue to move in the direction of the breeze. It merely catches an unusual amount of the unbalanced force of the breeze, and revolves in an eccentric path, whereas the central vortex of the pool remains relatively unaffected by the same influence. The dense planets revolving about the sun can be blown off into an oval path by the sidereal breeze, but the solar system as a whole, with the sun as the vortex of the solar pool, revolves about the centre of the sidereal whirlpool in a different curve; and while the sun may oscillate slightly, it certainly does not move in a way that corresponds with the oval irregularities of any of the planets.

We shall in the next chapter consider briefly the mechanics of spherical whirlpools of evaporation. The laws of planetary motions refer to the orbits after the planets have attained paths which are practically repetitive and, in the average, perfectly balanced with the environment. Let us now see whether these discovered laws confirm or deny the theory that the conditions of a spherical whirlpool of evaporation may create planetary motions corresponding with Kepler's laws.

CHAPTER XXVII

DERIVING KEPLER'S LAWS FROM THE CORPUSCULAR THEORY

> Knowing that you have in your body but a small bit of the earth which is vast, and a little of the water which is vast . . . do you think that you alone by some good fortune seized for yourself intelligence which exists nowhere else? And that this immense and countless assemblage of things is maintained in order by something devoid of reason?
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> SOCRATES: *Memorabilium.*

KEPLER developed three laws of planetary motions. The first gives the shape of the orbits; the second associates the motions of different parts in a mathematical relationship; and the third, which we must especially consider, formulates the relative times of revolutions at different distances from the sun. These laws are: (1) The orbit of every planet is an ellipse, the centre of the sun being one of the foci; (2) the radius-vector, or line drawn from any planet to the sun, describes equal areas in equal times; (3) the squares of the times of the planets' revolutions are as the cubes of their mean distances from the sun.

The planetary paths are oval, but this does not alter essentially the average time of revolution. The eccentricity is very little—that of the earth being .01674, and of Venus only .00681—and the influences which accelerate, retard in other opposite symmetrical parts. In considering Kepler's third law, therefore, we need take no account of these slight eccentricities, nor need we consider that the orbital velocities vary. Since, however, it is generally admitted that the laws of Kepler apply closely to the motions of the planets, the theory that the material universe is a dissolving and restrained pressure-pool must be tested by questioning whether the phenomena of such a universe would take place in harmony with known laws. Or, to put the query differently: What is the law of the times of revolutions of bodies at different distances from the vortex of such a pressure-pool? If revolutions should correspond closely with the planetary motions, then we may be more assured of our theory of conditions.

Here, before me, is a hollow glass sphere filled with a transparent fluid in which are small white particles like flakes of paper. When I shake this toy, these particles form a dense cloud like a miniature snowstorm. The flakes are heavier than the fluid, and after being stirred they sink gradually; but if there were no earth-gravity, or if the particles had the exact density of the fluid, they would remain suspended and float with the fluid-current.

There is no appreciable evaporation of the water within this sphere, hence there are no observable movements of the flakes in response to such a relief of pressure. Nor do the flakes attract one another appreciably. Microscopic observation, however, tells us that the molecules of the fluid supporting the flakes forever move and collide, both with one another and with the white specks. The flakes are vibrating, therefore, in response to these hammerings; but we cannot see the movement. They are floating placidly in a fluid so transparent that our unaided eyes cannot detect it. Only our reason, observing the suspension of the flakes, and their curving motions, informs us of the presence of the supporting medium. Here that which is sensed proves the unsensed. It is odd that we do not also permit our reason to assure us of the presence of the invisible fluid that envelops the planets—a fluid within which, and under whose compulsions, these orbs revolve in stately curves.

We conclude then, from the general experience and not from actual test, that there must be a fluid within this desk-weight. We realize, too, that this fluid-volume is restrained to the shape of the hollow sphere by the repelling forces of the concave walls, and that these forces may, in general, be said to converge upon the centre of the fluid-mass. These external forces which repeatedly reverse the motions of the interior molecules are the causes of the constant energy-delivery within this volume. This same sort of general energy-equilibrium is found within all fluid volumes—an energy-balance disturbed in the average only by variations in the pressures from the outside, or from changes in the inertias of the matter inside.

If the flakes were very diffuse-volumes, like bubbles of air, they would still be held in compact organization by the blows which the fluid-molecules repeatedly deliver against all interior volumes. We seem justified in supposing, then, that the converging impulses (when all of them, both visible and invisible, are being considered) supply the white specks with their ''cohesiveness'', or tendency to remain in permanent formation. Except for the blows from without, the tiny oscillating parts composing both the white flakes and the fluid would separate freely into space. They would become sufficiently disentangled from structural necessities to pass through the glass wall singly—or as light-rays do—and wander away.

As things are, however, the specks, in relatively large cohesive formations, float in a fluid composed of relatively large molecules. Though inert, they are surrounded and pressed against and vibrated upon from every side. The average energy-expression of the fluid-molecules against them, moreover, is to-day about as it was last year.

If one should wonder whence comes this constantly repeated force of compression, he must conclude, as already intimated, that it is received from the motions of particles composing the glass walls, for only by the use of real energy may the motions of matter-bodies be reversed. And these glass walls, in turn, must receive from forces exterior to them the energy which they deliver. We thus trace farther and farther the source of the energy of the repeatedly reversed motions, until, finally, at the bounds of the material universe, we postulate the presence of an accomplishing Cause whose purposeful influence is intimately felt here by us, and even seen here as we watch these drifting flakes of white.

If the glass sphere on the desk were the whole universe, the hammering of the interior fluid-molecules would break its walls unless they, in turn, were constantly supplied with energy sufficient to reverse the motions of the fluid-molecules —or at least to bring them to rest. Without this constantly received ability to resist, the globe would burst, the limited spherical formation would not be maintained, and the fluid-molecules would move off indefinitely into space. But, since no glass wall is a source of continuous energy-expression in one direction only; and since mechanics tells us that no material structure that remains relatively at rest (unless receiving its power from a source outside of itself), can reverse or deflect the movement of another matter-body without being itself moved by the collision; since the Conservation doctrine informs us also that within the realms where pure mechanics has sway, action and reaction are equal, we must (unless we imagine some one-way influence such as the unreal curved space-time continuum that Einstein postulates), suppose that the power which reverses the fluid-molecules from year to year is to be found outside the physical walls of this glass sphere, and outside the walls of any other physical globe that we may imagine.

Have we reasoned too fast? We believe a mental Cause restricts moving matter, and we think this because the source of the restraint seems to lie outside the volume containing the matter. But why should the matter require restraint? Why should it not remain at rest—or else dissipate itself endlessly? Surely we must know that there is a non-material Cause from the fact that there are material movements to be restrained! Except as a mental principle moved and then restricted matter, these fluid-molecules and corpuscles everywhere would not be moving. Nor will attractions at a distance account for these repeated oscillating motions in reversed cycles. Except, therefore, as a mental Cause repeatedly reverses the movements of matter there never would be this fairly permanent field of uniform pressure, never this definitely limited spherical volume, never this restricted pool of moving parts. Except for a mental Presence and Power there would be no mechanical phenomena. Elsewhere in these pages these ideas have been advanced, and we hope to reach a final confirmation by considering the phenomena within a miniature pool of dissolving matter. Before us, then, is the glass desk-weight. We believe that the motions of the white flakes within it, floated as they are by an invisible fluid, will tell us something about the orbits in the larger energy-pool in which the planets and stars float. Let us see.

When we shake the globe the impulse makes the flakes rotate in what appear to be regular curves, or circles; hence we know that the invisible fluid also moves in circles. If we shake the globe in various ways, we shall originate many motions in different directions. Obviously, however, because many of these motions are in opposition, they cannot all continue. Indeed, they can scarcely begin, for the fluid is relatively incompressible, and the forces of two streams starting towards the same space from opposite directions will quickly cancel each other. Shortly after the shaking ceases it will be found that the specks move in circular paths in parallel planes. These paths, therefore, must represent the final component of all the impulses given them by the fluid-molecules. Further, the specks show no indications of displaying "attractive" or "repulsive" forces towards one another. Nor did we touch them when we shook the globe. Their movements, therefore, are interesting chiefly because they completely reveal the component-effect of the fluid-forces. They are being affected solely through the medium of the fluid-energies.

Granting the intermittent character of the blows of the fluid-molecules against the flakes, reason informs us that the specks revolve in polygonal paths closely approximating circles. Observation tells us that the centre of rotation is approximately the diametrical axis of the sphere; that all the orbits lie in approximately parallel planes; and that each speck remains in one plane. The flakes neither change their planes nor collide. Flakes in contiguous planes, while passing extremely close to one another, are not "attracted" to move closer. They revolve, so far as we can see, symmetrically, and yet the orbits are created entirely by forces received from the invisible fluid—first the twisting energy of the shaking which causes the visible revolution, and secondly, the forces of restraint.

The greater part of the force of revolution—that part, at least, which makes the revolution visible—has, in this case, been added artificially, and is not necessarily a repeated influence. The force of revolution, moreover, is opposed to the natural forces which converge upon the centre of the sphere; and since these forces of restraint are repeatedly given, part of the added and unbalanced energy of the revolution is being cancelled from moment to moment. For this reason, if left quiet after their shaking, the specks will revolve more and more slowly, until, finally, they will seem to stop entirely. One then tends to conclude, incorrectly perhaps, that all revolution has ceased. The fact is usually overlooked that the effect of a repeated Evolution of matter might create anew a component force of revolution which is not in conflict with the converging forces, but is a product of them. And the converging motions might themselves bring about a transformation of matter which might tend to induce rotations with varying velocities at different distances from the point of transformation.

Suppose now that a tube is inserted into the glass sphere, and that, through it, an additional speck is injected into the revolving fluid. What would happen to it? Certainly this flake, upon coming out of the tube, will not continue moving in a straight line, but it will soon be revolving in one of the fluid planes. It will soon become a planetary body indistinguishable from the others. At some point, the exact position depending upon the relative density of the speck, and upon the velocity of its ingress, this added particle will have been deprived of all its initial velocity, and, from that time forward, it will revolve conventionally in the fluid plane of which it then happens to be a part. No instrument can then detect the difference between its orbit and that of every other speck in this same plane at this mean distance from the centre. And, since none of the orbits is visibly eccentric, whatever the velocity or angle of ingress may be, the incoming flake will finally be forced to accept the balance of the normal or circular path. If there should be a slight eccentricity, it must come from a cause which affects all the volume alike. The eccentricity cannot be due to an inherited radial velocity of the flake still persisting. An ordinary mechanical cause, one time expressed, cannot create a repeating oval, and therefore unbalanced, orbit within any part of restrained fluid-pool held in restrained balance by "absolute" exterior forces.

If, moreover, one of these revolving flakes should be stopped and then released, it will not be "attracted" towards the centre of mass, but will be urged into motion by the moving current of invisible fluid-molecules. Quickly after its release it will be found encircling the centre of the globe in approximately its former path, and with a velocity normal to this distance from the centre. The energy consumed in renewing its motion will be deductible from the total energy of the sphere, and, thereafter, in this pool to which unbalanced energy is not constantly being given, each flake will revolve somewhat more slowly. Time is a factor, however, in all such changes.

This glass sphere, with its fluid and its flakes, differs from the universe at large. The white substance has approximately the same density as the relatively incompressible current which floats it, whereas the planets of our solar system are thousands of times denser than the current which floats them around the sun. In our world-system, moreover, the different planets vary in density. In the desk-set, too, so far as we can see, there are no motions that do not finally cease. The orbital motions do not seem to continue as do the motions of the solar system. The fluid of this desk-weight, moreover, is affected by the earth's gravitation, although, obviously, the universe as a whole cannot be affected by a mechanical influence acting on it from one side only. If the fluid in the glass sphere evaporates, moreover, the effect of the evaporation is too slight to be observed. We cannot detect in this globe any of the delicate currents and unbalanced energy-tendencies that might exist because of a material Evolution. And, even if the sphere could be observed with that nicety which would disclose the slightest influences within it, the situation would still differ somewhat from the larger world that we wish to interpret, for we are looking at this glass ball from without, as it exists *within* a world, and with world-influences operating upon it, whereas we cannot thus look at the universal sphere.

Here we are, immersed within a pool, tiny bits of matter containing life, and residing on a relatively tiny mass. We cannot see the boundaries beyond which there is no matter; we cannot observe the general movements of the clusters of stars; and our vision is too gross even to detect the diffuse currents surrounding and impelling the earth. Our observation of phenomena is so limited in many ways that we do not always realize that we are being compressed, vibrated, and impelled. We observe a few of the phenomena which appear to be true of the skin of our little planet, and some of the general relationships of the other planets with one another and with the sun; but here our experience ends. In this predicament we must use our imagination. We must assume first, and verify later; we must first form premises and postulates, and then try to confirm these speculations. And we must take the near-by situation as an analogy in order to consider the conditions at the far bound. As Thoreau has said: ''All perception of truth is the detection of an analogy; we reason from our hands to our heads.'' We must judge widely from what is close at hand. We must conclude from this little sphere of pressures on the desk before our eyes what the laws and conditions must be of the universe surrounding us.

And we can properly draw just such inferences, for an intimacy permeates and relates all nature. William James puts it thus: ''The inmost nature of the reality is congenial to *powers* which you possess.''[1] And again, ''Surely, if the universe is reasonable (and we must believe that it is so), it must be susceptible, potentially at least, of being reasoned out to the last drop without residuum.''[2] Plato; too, asserted that things are knowable. ''They are knowable, because, being from one, things correspond.'' Or, in the words of Emerson, ''The possibility of interpretation lies in the identity of the observer with the observed. Each material thing has its celestial side; has its translation, through humanity, into the spiritual and necessary sphere where it plays a part as indestructible as any other."[3] And it was the favourite maxim of Malpighi that "Nature exists entire in leasts."

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[1] William James: Essay, *The Sentiment of Nationality.*

[2] William James: *Reflex Action and Theism.*

Let us, therefore, pursue our analogy with the desk weight even though our perceptions are too gross to permit us to detect its most finely drawn tendencies. Let us, however, imaginatively alter our concept to make the conditions more closely resemble those of the large world. Let us disregard the unbalanced influence of the earth's gravitation, and think of the glass sphere as though it existed in some place where it was affected (as is the universe as a whole) by universally restraining forces. Let us imagine, too, that the supporting fluid is not water, but some diffuse gas, which, for a reason yet to be given, slowly revolves and carries the white specks with it in planetary orbits. Of course the individual molecules of the diffuse fluid pound back and forth from limit to limit in straight-lines (straight-lines, that is to say, until two of them collide and deflect), and with velocity enormously greater than that of any natural or artificial revolution. The natural tendency to revolution, indeed, if there be one, is the final uncompensated or component effect of all the straight-line movements this way and that. Since, however, according to the postulate, the energies of the straight-line motions (as well as the component of them) are renewed and continued minute after minute (the gas-particles repeatedly receiving fresh impulses from the restraining walls), if there is ever any "absolute" tendency to revolution it will continue indefinitely.

Now the straight-line motions must be approximately balanced with regard to the centre of the sphere, for, otherwise, the speed of revolution would be much greater than it is. Part of the straight-line motions, however, must be unbalanced in respect of this centre, for, otherwise, there would be none of that revolution which we have assumed to exist. It is first our problem to account for the unbalanced force which will produce a tendency to revolution even in this glass sphere; and we must then decide whether a universe thus conditioned will display orbital motions corresponding with Kepler's laws.

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[3] R. W. Emerson: Essay, *Uses of Great Men.*

The molecules of the gas fluid, as we have said, will move with velocities enormously greater than the revolving motions of the solid flakes which they pound against. Indeed, these flakes as wholes do not move perceptibly closer to, and then farther from, the centre of the sphere. Normally, that is, when the globe is not shaken, the range of movements within which the flakes become balanced is almost indetectible, and when abnormal movement is induced we see only the slow revolutions which surrender energy and become slower moment by moment, until finally, once more, revolution is indetectible. Always the particles composing the structures of the flakes remain within the bounds of their atoms, however, and never come into contact with the outer walls. Hence they are never "charged" *directly* with their reversed motions. They receive their energies of motion from collisions with other inert corpuscles—themselves moved.

Because an atom of the specks of paper is relatively dense, even though the corpuscles composing it are constantly being struck by the extraordinarily swift particles of the more diffuse current, these parts remain year after year within the one structure. Apparently the tiny parts of the paper move rapidly towards the inside of the paper-formation when struck by the swift particles of the outside, but they soon surrender this initial velocity to the parts of the dense and fairly permanent structure. Thus these chemical structures, we may say, are held "compressed" almost infinitely. But free corpuscles roam farther. Some of them reach the very bounds, and of these it may be said that the smallest formation of which they form a relatively permanent part is the universe itself.

This artificially created and abnormal revolving motion within the desk weight will, we say, soon be reduced by internal collisions to the point of normality where the motion is imperceptible. It is different in the immense reaches of the solar system, for there the normal revolving motions are distinguishable. They can be examined and charted, and because they are due to repeated activities of dependably uniform forces, they can be brought into dependable average systems. We notice and measure one situation, whereas we do not detect, and cannot chart or "know", the other. Yet we can test the theory artificially in the glass sphere where the normal revolution is indetectible but where our knowledge of the whole and its details is sufficient. We may then conclude that the analogy with the universe is so perfect that we shall feel justified in a firm opinion about the conditions between worlds, even though the relations there are so extended that we cannot experience them directly, nor even test them empirically in satisfying fashion. We may thus reach a proper conclusion about a situation beyond direct experience.

If the flakes of the desk weight were denser than the supporting fluid, so faint is the average concentrating force within it that a small artificial revolution would end with all the flakes rubbing against the wall. This principle would be true of the solar system, also, if it had a rigid wall that limited it sufficiently, and if all the planets were of the same and sufficient density. If, however, as things are, the earth, Mars, Venus, and the other planets, were artificially accelerated, and reached velocities far exceeding those now normal to them, their orbits would expand until they reached those distances where their motions and densities would fulfil the requirements of a new energy-equilibrium—that is to say, they would attain those different distances where the forces available for deflecting their masses into their bending paths, would from moment to moment equal and balance the forces which (at these respective distances from the centre) persistently created the orbital velocity. This is the theory. In practice, however, before the planets could reach enormously extended orbits, they would probably come into the influence of some other system, and thus, if accelerated sufficiently, they might even tend to cease revolving about the sun. We must assume, nevertheless, that the mass-volume of each planet now regulates its mean distances from the centre of the restrained system in which it revolves, for it must remain in equilibrium with the forces causing revolution; and, as is discovered, these forces are inversely less as the square of the distance from the centre is greater. A lengthy discussion of this principle, however, is inappropriate here. We wish to understand the law and principle of the persistent force which induces revolution, and before we can analyze this force we must first identify it.

Can any persisting natural process be conceived which will cause these flakes to move in repeating elliptical orbits, and with related velocities varying according to Kepler's laws? If such conditions may be conceived, then they may be found to apply to and explain motions of the solar system.

We have suggested that the Evolution of matter is the process which we are seeking. It is our problem, therefore, to decide whether such an influence could induce the planetary orbits. As the first step let us introduce evolution imaginatively into the relationships of the glass sphere to see whether elliptical orbits will be promoted, and whether it will cause dense mass to draw near dense mass in some cases and not in others. The apples invariably drop from the tree, but the moon does not come appreciably nearer the earth. Indeed, electrons even leave radium in opposition to gravity; and water seeps upward into a cloth. Are these different results consistent with our postulate of conditions? Will the transmutation of inertia from the material to the spiritual, when taking place repeatedly in a restrained and moving mass of matter-bodies, give such results?

And will a persisting Evolution of inertia account also for the persisting revolutions of the planets? Will the force of this revolution develop from the very marrow of Evolution, and may we therefore dispense with the belief that planets move with velocities inherited in full, with energies never reduced but only deflected? Will this theory explain where the present hypothesis fails? Will it tell us, for example, how it was that the planets when exploded (as some believe) from the sun (the ejection being aided, perhaps, by the "attraction" of a closely passing star, which by its "pull" even started the planets rotating on their own axis as they now still do with supposedly undiminished vigor) stopped moving away, and, instead of either dispersing indefinitely into space or returning to the source which attracted them, assumed their present almost circular orbits? Let us imagine boldly, then, and see what will follow.

We have agreed that were it possible for a vacuum to be created by collisions within what was previously inert matter (our postulate in this case), then the larger the structure,—provided it has more than average density,—the greater will be the vacuum it displays from moment to moment, and, therefore, the more will a particle of the surrounding energy-medium be forced towards it by the reduction in the average unbalanced pressure thus developed within the surrounding pool. The power of concentration, therefore, so far and so long as it is real, will be greater in proportion to the greater mass of the denser volume. This corresponds in general terms with the conventional theory, for gravity also increases with mass. The repeated evolutions of matter and its inertia, we say, are the indirect causes of planetary revolutions, and they also account for such tendencies to concentrations as there are. The evolutions themselves are the products of the collisions of physical bodies.

Some of the corpuscles have collided unusually, without being dissolved, however, and have lost unusually of their normal velocities and energies. These corpuscles compose our seemingly permanent atomic structures. The repeated swift blows from the outside against the relatively sluggish particles in the denser atoms explain the perpetuation of these compressed and dense structures. Still, we do not understand why these denser structures move in oval orbits. Why should not the dissolution of matter take place evenly and placidly within a sphere of uniform density? Surely, if this uniformity were possible there would be no extended orbital movements, for there would be no unbalanced force-components to create them. Why does not the world dissolve quietly like a pond in a sun-baked field, which steams to heaven without a perceptible whirl anywhere? Can we explain the facts, we wonder, through the postulate of uneven Evolution?

Certainly there *is* an uneven distribution of matter. The world is not like the sun-baked pond. There is more matter in a cubic inch of lead than in the same volume of water, and more matter in a cubic inch of sun or earth than there is in the spaces between them. Will this state of unbalanced densities, coupled with the postulate of faster material dissolution in the denser bodies, cause the planetary bodies to revolve everywhere according to Kepler's laws? Is the persisting measure of unbalanced energy that may be derived in an energy-pool from a persisting Evolution of matter, sufficient to drive the planets?

If Evolution can cause orbital movements, surely we may then accept our postulate of dissolving inertia as true. We have long admitted the Evolution of species, but have not yet agreed that this change is an offshoot of the more fundamental process of a transformation of matter into spirit. Nor have we yet admitted that there are "absolute" motions —movements from which an Evolution might proceed. This admission, to be sure, would make a formidable breach in the Conservation principle. Indeed, if the restrictions and reversals of matter at bounds are really due to an unmechanical Power, there remains left to us no important idea of Conservation. Rather we must accept its opposite, the idea of the constant renewal of purposed motion. We therefore ask now for a complete surrender of the principle of mechanical Conservation in general terms, for in the concept of a power-created world we feel that we gain an understanding of the source of that unbalanced energy which drives the earth repeatedly about the sun, and which reverses the direction of her motion by the use of an enormous amount of unbalanced force.

Suppose we insert a glass tube to the centre of the desk weight and repeatedly withdraw portions of one of the flakes. We shall then have created a mechanical vacuum within an energy-pool, and the particles of the surrounding fluid will be impelled towards this vacuum by the excess of pressure from other parts of the pressure-sphere. There will be movements by which the energy-balances of the pool will be restored, and the effects of the adjustments will spread into every part of the fluid-volume—even to the restraining walls. Nor do we require an elaborate calculation to prove that the average bit of matter in the surrounding fluid will move inward with a force that decreases as the distance from the point of vacuum-making becomes greater. At any certain distance, indeed, the chance that any certain particle will be the one to move to compensate the lack of energy in the central volume will be inversely proportional to the number of particles in this layer.

If we consider the spherical layer which contains exactly one hundred particles, then, since the movement of a single particle will compensate the creation of the unit vacuum, and since only one particle can move, there is but one chance in a hundred that a certain particle will move. Or we may put it differently and say that, in the *average,* each particle of the hundred will be affected by a hundredth part of the total amount of the unbalanced force resulting from each withdrawal of a central particle. If there should be a thousand particles in a more distant spherical layer surrounding the place of withdrawal, the concentrating force on each particle will average, for any reasonably long time-interval, a thousandth part of the total force of concentration due to the single withdrawal.

The principle is true as a generalization regardless of how many times the single withdrawal is repeated. We may say, therefore, that the concentrating force acting during a certain period on each particle surrounding the place of withdrawal is inversely proportional to the number of particles at that average distance. If, however, the intervening fluid is of approximately uniform density, then, according to geometry, the number of particles in each spherical layer will vary directly as the square of the radius of the sphere. By combining these principles, we learn, in general terms, that the force of concentration inside a pressure-pool towards the centre of a denser mass varies *in the average* inversely as the square of the distance from this centre. This conforms with the conventional law of gravity except that we are not assuming that the unbalanced force is being created *continuously.* Our geometrical formulas, and our laws of gravity are not quite accurate, for, contrary to assumption, every structure and every volume is filled with separated granules.

The geometrical theorems are based upon the erroneous premise of solid physical continuums. When the diameter of a single corpuscle is taken as the unit, or "one" (1), of distance, and when these tiny spheres are in their most compact formation, and pressed snugly against one another, the outside diameter of the spherical layer of corpuscles touching the central particle should be represented by the number "three" (3). According to geometry, a sphere with diameter "three" (3) should contain nine times as much matter as the sphere with diameter "one" (1). This will not be the case, however, for spheres cannot pack together snugly fitting like cubes, and there will be a considerable amount of unoccupied volume inside the surface of the sphere having diameter "three" (3), and none within the sphere of diameter "one" (1). For this reason neither the amount of matter in the various spherical layers nor the law of the force of its convergence will vary exactly in accord with the conventional formula. The formula is especially inaccurate when small dimensions are being considered.

The failure of the law to apply to the smallest spaces, however, should not surprise us, but rather should add to our conviction that the new theory is sound, for fine experiences have already developed facts unexplained on the assumption that gravitation is continuous, that it emanates uniformly in every direction from the exact centre of mass, or that it follows the inverse square law when two corpuscles are very close together.

Neither can the cancellations of matter through Evolution be continuous, for, if they were, the substance of the world would immediately disappear. Evidently, then, since the events of Evolution are intermittent, there are intervals during which gravitational force is not being expressed. This, though contrary to the usual theory, corresponds with the most powerful microscopic observation of the smallest particles. The inverse square law of gravity is not exactly true, therefore, yet may be used satisfactorily in the extended space-relationships. The inaccuracy increases as the space-relationships approach unity. These facts, now known to experience, conform to this evolutionary theory.

A similar inverse square law of concentration applies grossly to the force of the vacuum-cleaner. It is the law, as well, of the force which presses a piece of iron towards a magnet. In reverse, it is the law of the forces which radiate from explosions, of the energies which dissipate in the form of sound, and even of the light-energy coming from a very distant source. Whenever the medium which transmits energy is itself oscillating uniformly, we may always say *in general terms* that less energy is received by an object in inverse proportion to the square of the distance. In none of these cases, however, is the law more than relatively accurate, and it breaks down badly when used for tiny spaces or for very short intervals.

If a negative energy-volume, or vacuum, is created within a limited energy-pool, the origin of the force causing unbalanced movement towards this point may be traced farther and farther from the centre until finally the bounds of the pool are reached. The unbalanced force is virtually created by energy received from the outside. And although this force is not of unlimited power and scope, there is, nevertheless, no limit (within the bounds of the physical pool) to the range through which the principle of the change in the normal energy-balance is expressed. Likewise, an unusual pressure in the water of the ocean spreads from one continent to the other. We can say, therefore, that the energy-balance of the universal pool extends to the farthest star and dust-speck, and to the space beyond which there is no matter; and that changes in this balance have effects extending likewise. There is no other possibility.

The force which creates gravity, then, may be traced to the farthest reaches of the material universe, just as the unbalanced force of concentration in the desk-weight (the force which acts when a particle is withdrawn) may be traced from the point of vacuum to the glass walls, and then beyond these walls indefinitely.

The effect of a reduction in the usual energy-expression in one spot radiates to the limits of the pool through the passage of the unbalanced energy-state from one oscillating particle of matter to another. Thus, if a particle should be withdrawn many times from the centre of the glass sphere, one of the layer of nearby corpuscles will quickly move toward the point of withdrawal, and this movement will leave an energy-and-matter-vacuum, but one that occurs less frequently in the average in this particular spot away from the centre than that one created by the central withdrawal. And this external vacuum has a correspondingly reduced negative influence on some other particle in the spherical layer next beyond, and so on. For this reason, when an oscillating corpuscle is released from some of the usual collisions by the vacuum-creating on one side only, and is therefore pressed by unbalanced energy towards this point of relief, the unbalanced tendency to motion spreads,— but with an energy which reduces with distance,—to the very bounds of the space containing matter. The total amount of energy expressed when a vacuum is created but one time, is not infinite, but is measurable in terms of the number of corpuscles affected, and by their average expression of unbalanced energy. And also, since the vacuum-creating is intermittent, the total expression of the force of gravity accumulates at intervals.

Also contrary to classic belief, time is required for the unbalanced force of gravity to reach a piece of matter at some distance from the point of vacuum-making. Only if the creation of the unbalanced mechanical vacuum is being repeated rapidly, and at regular intervals, as in the case of the vacuum-cleaner, does the force of concentration seem to act instantly upon the dust-particles within its range of influence. If, however, a vacuum-cleaner should be stopped long enough for all movements to cease, and should then be started again, appreciable time will be required for the effect to reach a distant point. The same principle doubtless applies to the electric magnet, to the earth's gravity, and to all supposed ''attractions'', for all of these (we believe) represent the impulses of separated corpuscles which are moving only because unbalanced energies have been created in an otherwise balanced energy-pool. All such forces are granular and discontinuous, and in respect to them time is required for a force greater than unity to be expressed—and also for the force to reach a point more distant than unity. When the current of electricity is turned on, the attraction of the electric magnet does not immediately reach the piece of iron at a distance.

Another principle should be noted. When two dust-particles close together are relatively far from the vacuum-cleaner, the concentrating force appears to affect both of them equally, although a delicate experiment would prove that the particle farther from the vacuum (and therefore taking part in a larger circumference) will receive during any certain average time fewer of the impulses of unbalanced energy. The earth's force of gravity will act with approximately equal force upon every hydrogen-atom upon its surface—but only when the force is averaged through considerable time. Gravity therefore, as averaged, affects equally all the atoms of a piece of iron that are equally distant from the centre of ''attraction'', whether the atoms are lumped into a concentrated sphere of small cross-sections, or whether the lump be flattened out into a thin sheet. That is to say, we learn from experiment that gravity acts upon a body approximately in proportion to its total mass, and not in proportion to the area of its horizontal section. Gravitational mass is proportional to inertial mass in any certain ''field''. But, why is this so even as a gross experience?

When one of the hydrogen-atoms composing either a piece of iron or a gas-balloon is impelled by a diminution of the usual resistance to move towards the centre of the earth, its movement will be followed quickly by the movement of the particle farther away from the vacuum. Indeed, it is the unbalanced force of the blow of one of the oscillating exterior particles that has made the interior particle move towards the vacuum. Except that this exterior oscillating corpuscle gave repeated blows to the interior one, the pressure of vacuum would create no movement in the particle closest to it, and, therefore, to no particles anywhere. As things are, however, the ripple of unbalanced motion, due to the unusual vacuum of energy on one side only, will spread *in time* entirely through the volume of oscillating particles. The speed of the spread will be in direct proportion to the average rapidity of oscillation (in the line-direction of the unbalanced energy) of the corpuscles creating the effect, for no time is consumed in the passage of motion from one to the other on contact. This theory is supported by the fact that sound-waves are translated through air at exactly the average speed of the energy that passes in this direction through the contacts of air-molecules with one another. Through relatively long periods, therefore, every relief of pressure affects each of two contiguous corpuscles in approximately the same way, even if one lies behind the other. On this account, the corpuscles of diffuse volumes are affected by gravity in the same way as those constituting denser volumes.

The tendency to unbalanced movement, we hold, is caused by an unusual diminution of energy-expression within an unusually dense portion of a previously balanced energy-pool. According to this principle, the relatively greater or less density of the corpuscles within a certain volume has no effect upon its normal energy-relationship with the rest of the pool. That is to say, diffuse and dense volumes of equal size express equal amounts of energy toward the rest of the pool. Only thus do they maintain their respective structures and average volumes within it. This principle helps to explain the fact that two equal volumes containing unequal masses fall toward the earth (through vacuum) with the same amounts of gravitational acceleration (and therefore of kinetic energies), and that inertial masses and gravitational masses are proportional. The balance of the pool of pressure *is maintained as an energy-balance, and not as a mass-balance.* This is the important consideration. Equal energy-volumes, and not equal masses, move to satisfy a situation in which energy has become unbalanced; and thus the movements of equal volumes of any cohesive structure similarly balance an energy-void. For this reason the parts of all volumes move equally when the structure is submitted to gravitational attraction.

In the more diffuse structures the separate corpuscles oscillate with more velocity than those of the denser structure, and on account of this greater speed each corpuscle of the diffuse structure offers more resistance to aggression. The swifter corpuscles, however, must receive more energy from the environment, for, otherwise, their motions would not be stopped and reversed. Nevertheless, if we refer to the structures as wholes we find that translations of equal volumes of any of them into an energy-void at equal speeds will equally promote the restoration of the energy-balances there. We now perceive why a light body falls in vacuum as rapidly as a heavy one, and why a flat sheet of metal falls as rapidly as a sphere of metal of equal mass. We may conclude, also, that if each unit of mass of a balanced structure is affected equally by gravity, whatever may be the nature of the structure of which it is a permanent part, the action of gravity on every structure is directly proportional to its inertial mass. This signifies that the inertial and gravitational masses of relatively gross bodies of fairl permanent structure bear a constant relationship in any gravitational ''field''.

These principles, to be sure, apply only to average states, to situations wherein times and distances are rather grossly generalized. Yet they apply accurately enough to those semi-permanent atomic structures of hydrogen atoms composing our elements. This seeming conformity with generalized experience is sufficient, however, to satisfy us that our theory is sound, for the statement that gravitational and inertial masses are proportional is true only with regard to composite structures under grossly averaged conditions. The new theory conforms with the old where it should and departs from the old law where it should. For this reason we have faith in it.

We find, then, that we do not need Professor Einstein's explanation that gravitational mass is of like kind to the constant acceleration of inertial mass. Not a mysteriously unceasing increase of acceleration from an unknown source of power; not a principle which does not explain the different directions of gravity in respect of one structure; not a principle which fails in the smaller relations; but the result of an Evolution of inertia inside a normally balanced pressure-pool (when conditions are grossly averaged, at least) gives the explanation of the correspondence of inertial with gravitational mass.

This principle is exemplified in the movements of an air-balloon immersed in a pool of water. When the pressure of the pool is reduced in some particular direction the balloon is forced to move sidewise by the unbalanced force at exactly the same speed as an equal volume of water. All bits of matter composing the two volumes, provided that they are equally distant from the centre of withdrawal, are impelled by the unbalanced force of the pool to equal accelerations. Likewise similar bits of mass in the piece of lead and in the piece of cotton at the same distance from the gravitational centre feel the unbalanced force to the same extent, and each, therefore, transmits its weight-energy to another bit of matter with equal velocities and, therefore, with a force proportional to inertial mass. Two equal volumes when existing as self-contained wholes represent equal energy-contents, and therefore move the same under influences of unbalanced forces in the pool, and then deliver the momenta of these movements in proportion to their respective inertias. The more diffuse air-volume of the balloon has fewer and faster oscillating parts in its atoms, but the movement of an average portion of its self-contained volume as a whole compensates the disturbed energy-balance of an adjacent volume equally as well as the movement at the same velocity of a similar volume of denser but more sluggish and yet cohesive, water.

The evolutionary theory, involving as it does the concept of a discontinuous gravitational force, has now afforded simple explanations of two of the important, but generalized, gravitational principles. The assumption that gravitation is due to the blows of granular particles does call, however, for changes in the law, and these revisions become drastic when the principle is applied to the activities of single corpuscles.

Professor Bertrand Russell remarks that ". . . the laws of electromagnetism suffer a discontinuity when we reach the surface of an electron or proton."[1] This "discontinuity", moreover, corresponds to nothing in the Relativity hypothesis; nor is it compatible with the idea that gravity is a continuously acting force.

The Relativity hypothesis may perhaps explain satisfactorily to some minds why light-rays curve constantly in one

[1] Bertrand Russell: *The Analysis of Matter*, p. 121.

direction under the influence of nothing more potent than curved space-time—itself affected it is said at a distance by the passive presence of unusual mass. It may even explain, as Professor Russell thinks it does, how the earth may proceed around the sun in an ellipse even though there is no attraction of the sun "pulling" it.

He writes:

> A planet, in the new theory, is moving freely, whereas in the old theory it was subject to a central force directed towards the sun. In the old theory, the sun was like a despotic government, emitting decrees from the metropolis; in the new, the solar system is like the society of Kropotkin's dream, in which everybody does what he prefers at each moment, and the result is perfect order.[1]

Relativity may perhaps permit us to escape from the necessity of believing in certain kinds of forces acting at a distance, and to this extent it may be pleasing. Yet it is objectionable in that it adds more mystery than it eliminates. It even introduces its own type of "force at a distance." Nor do its explanations cover the entire mechanical situation. The seeming explanation of the large-scale event cannot be used to translate the small-scale event, and Relativity has no explanation for the sources of its "absolute" mechanical power. Evidently, therefore, the formulations of Relativity are generalizations adapted to experience, and are of little value philosophically. The theory may be useful for a time as a means of reaching a correct answer in some particular case, but it is not of universal application, is not fundamentally sound, and will likely soon be displaced. No mentally inconceivable or purely mechanistic premise can explain the universe. In a later chapter we shall consider light-rays, and try to interpret them in terms of the corpuscular hypothesis.

This corpuscular theory has not yet been questioned to see if it can disclose the law of the orbital revolutions of the planets. Newton supposed that orbital movements were due to undiminished, unresisted motions originating from energies expressed first at the time of creation. Neither Newton nor

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[1] *Ibid.*, p. 74.

Einstein has imagined that repeated expressions of ''absolute'' energy are required to account for the paths of the planets through the ''field'' of matter surrounding the sun. Both have seemed to think that motions might continue indefinitely back and forth in a restricted volume without the use of an independent and non-material power. Yet, how might the finite whole of the universe be held restrained without the repeated use of ''absolute'' Power? How might the air-molecules of the balloon be reversed repeatedly without the repeated use of new power? Or how might the earth be bent into its orbit around the sun and thus urged through a curving path of resistance without the use of ''absolute'' Force?

Professor Einstein does not explain the reversal of the air-molecules in the balloon, but he does intimate that space-time may be so curved in the neighborhood of the sun that the earth is deflected by the energetic walls of this curvature to move freely, as it does. He does not explain the curvature in the path of the moon (different from that of the earth) as it passes along part of the earth's former orbit; nor does he quite explain how it is that the earth gets its energy for brushing aside the field of matter through which it rushes. Nor did Newton explain this. Newton regarded his formula as no solution, but as a temporary law founded upon an irrational and therefore valuable theory. The hypothesis of gravity by Evolution, if it is to replace the theory of ''attraction'', therefore, must not only give us the approximately correct inverse square law, but it must also explain orbital motions and identify the source of their power.

If we were satisfied with the mathematical solutions we might pause here, for now that the inverse square law has been broadly derived from the evolutionary theory, the other laws of Kepler follow from the formulas. Any good mathematician will confirm this. The mathematicians, however, do not take into account the field of retarding resistances through which the planets pass, hence we cannot regard their mathematical demonstrations as sound. And, as we show elsewhere, the numerical formulations which they use for their proof are inaccurate, and do not interpret conditions exactly. Inherited velocity plus gravitational force cannot possibly account for the deflected and finally reversed motions of the planets as they pass around the sun. The white specks in the glass sphere could not possibly continue to revolve by themselves through the fluid—whether or not the centre attracted them, or whether the glass wall restrained them—unless the fluid-energy itself revolved and carried the specks in the same fashion that the water carries the log about the suck of the whirlpool. To account for planetary orbits, therefore, the orbital tendencies of the fluid-energy supporting the planets must be considered. We cannot suppose that inherited forces, *in addition* to the imagined forces of ''attraction'', will account for the movements about the sun. We must ascertain whether the theory of the Evolution of matter will provide a swirling energy-current in the oscillating corpuscles in the material fluid between worlds sufficient to urge the planets about the sun in their present oval paths.

The water of a pond shows no tendency to revolve, for its evaporation, at least when viewed rather grossly, is uniform. When a relatively large volume is considered, and the effect averaged through gross time, the relief of pressure following the evaporation of molecules in one spot is balanced by an equal relief somewhere else. In the very minute relationships of the water-molecules, however, the densities are really non-uniform, and the effect of the heat is non-uniform. Hence evaporation does originate unbalanced force followed by unusual motions of the molecules even in the pond, but the motions are so quickly compensated, and they traverse such tiny distances, that, in gross practices, they are of negligible importance.

The world-pool is different. In it, non-uniform densities pervade large volumes. The non-uniformities are so enormous, indeed, that we notice scarcely anything but them and their influences, and give little heed to the volumes where matter is very diffuse but spaced fairly uniformly. The unbalanced motions that follow non-uniform Evolution in the world-pool are most important to us, however, who live on the border between two volumes of non-uniform densities, hence we have adopted the unbalanced motion of a certain mass on the surface of the earth as our unit of force. We sometimes fail to observe that, in total, this unbalanced force is finally balanced. Nor do we perceive that to a larger vision the pool of the universe would not exhibit any more final measure of unbalanced motion or concentrating tendencies than the pond does as it steams there under the heat-rays.

Man on the surface of his earth, and with the thinner air above him, is in the midst of important force-expressions. In his relationship with the universe, however, he is like a microbe to whom a single molecule of water is relatively as large as the earth. This tiny microbe, when living on a water-molecule within the pond, might find itself in the very midst of "absolute" forces affecting its life profoundly. It might recognize many motions which we, interested only in relatively gross phenomena, might entirely overlook. Gravity is very real to us, however, for the unbalanced motions of gravity occur in those volumes where the environment is affected in a way appreciable to us. Our experience with gravity, therefore, is a study of local effects, or of balanced cycles of motion. Through time each of its effects is compensated. The weight of a pound of mass is never expressed upward, but, normally, other forces exactly equaling the pound of weight-force are expressed upward. The energy of the weight soon reaches a point of equilibrium with its environment where there is normally no average of unbalanced force tending to push it in any direction.

The sun and the planets being relatively dense volumes, the excessive Evolutions in them develop unusual tendencies to motions. There are dense star-systems, also, which induce similar tendencies to unbalanced motions. But, in the largest view, there is the centre of mass of the whole universe about which all motions must balance, just as the motions in the glass sphere, however irregular they are one by one, all balance as regards the spherical volume as a whole. Let us now trace these local motions a little more in detail.

It cannot be denied that the repeated withdrawals of inert particles from an energy-pool is sufficient to set up revolutions in the energy-volumes surrounding the point of withdrawals. This principle may be illustrated in any kitchen sink. When the sink drains, the water invariably swirls into the suck, and whirls faster when closer to the drain. Evidently the swirl begins because of some initial unbalanced condition in the energy-relationships of the molecules which follows the disappearance of some of the water. When a water-molecule disappears into the drain it leaves an unbalanced formation behind, and there is then a tendency to sidewise motion. The swirl begins at the point closest to the centre, and there the force is expressed in the most concentrated form. The nearest layer is first given the full sidewise impulse, and this tendency is transferred from one place to another by the contacts of the oscillating molecules, and soon it is felt at the very borders of the water-volume. With the first unbalanced impulse, a universal, but perhaps imperceptible, revolution begins, which is induced by a component of the unbalanced force of concentration, and each spherical layer receives its share; but since the spherical layers farther from the centre contain more particles, and has more inertia to be overcome, the rotary effect is built up proportionately less in time as the distance from the centre increases. If the tendency to revolution were expressed once only, all the initial movement would quickly subside, for the power of general restraint tends to cancel all expansive tangential motions. Only a certain limited range of oscillations back and forth are permitted to continue practically undiminished year after year, for if the tangential motions were allowed to continue indefinitely, the volume of the universe would indefinitely expand.

The "absolute" energies of restraint which are repeatedly expressed, must be repeatedly overcome to some extent, therefore, if any manifestation of sidewise motion is to continue appreciably. Thus, tangential impulse of the water in the sink is reduced by intermittent forces balanced as regards the centre of movement. In this way the sidewise motions are deflected into paths which in general have the drain as their focus. But, since each deflection absorbs some of the force (and motion) of the original impulse, unless the sidewise impulses were persistently repeated the revolutions would cease. When the withdrawals continue, the impulses to tangential movement are themselves repeated, however, and if, when the second impulse is received, the water-volume is still moving from the effect of the first expression of unbalanced forces, the velocity of revolution will be increased to a new maximum. Thus one might imagine that the repeated impulses would indefinitely increase the sidewise velocity. This would surely be the case unless there were counter-balancing influences. As stated, other "absolute" forces *are* being repeatedly expressed in this pool of pressure (and in every pool of pressure), and the opposition of these forces to tangential movements increases as the sidewise velocity becomes greater. Furthermore, the strength of the series of tangential impulses inducing the revolution becomes less whenever the movement is such that the body moves into a spherical layer farther from the centre of the force which produces the motion. The effect of the impulse reduces also with the increase of velocity of that which the energy-delivery has caused to move. Still other influences limit the speed of the tangential movement.

Let us suppose that in the sink the tangential motion carried the water appreciably farther from the drain. In such case, the density of the water-volume near the drain would be appreciably reduced. Yet this reduction of the density, and, therefore, of the energy-expression of this volume, would be contrary to the principle of equilibrium of a pool of pressure. It cannot continue indefinitely. Unlimited expansion of this sort is not possible if this pool is to remain finite. Whenever we grant that we are treating with a persisting and finite energy-pool, we must recognize, therefore, that the restraining forces oppose the indefinite continuation of tangential motion. We see this principle illustrated in the case of the desk weight. The paths of the flakes are quickly deflected into orbits by the general forces of restraint. We must, therefore, admit this *general* principle. At some stage the motions within every restrained, persisting, and therefore finite structure, must be balanced about the centre of mass of that structure, for otherwise it could not remain restrained.

Now the forces causing the tangential motions—like the forces of concentration of which they are components—reduce according to the inverse square law as the distance from the point of vacuum increases. For this reason, if the tangential motion of an atom should proceed, and should continue to increase the distance from the vortex, the sidewise impulses against it would steadily diminish in strength. Hence the greater the mean distance of the atom from the focus, the less opposed force will be required to deflect its tangential motion into a symmetrical orbit. A *symmetrical* path cannot be attained, however, until average acceleration has ceased, and this cannot come about until the average force opposing tangential acceleration within a certain gross time exactly equals the force tending to create sidewise motion during that same time. Similar principles regulate the speed of a motor-boat. It moves faster and faster through the water until at a certain maximum speed the accumulating resistances of each second balance the propulsive forces of that interval. At this stage the velocity can merely be maintained. No further average acceleration is possible. These are all principles relating to gross averages.

We conclude, therefore, that limited forces cannot create infinite velocities within a pool of pressure, nor can tangential impulses continue far undeflected or undiminished. Even if there is a repeated tangential impulse within an evaporating pool of pressure, it does not build up an ever-increasing velocity, but rather reaches a state of equilibrium with the restraining force-principle of the pool.

When this equilibrium finally obtains, not only has all acceleration ceased, but the motion will then have been brought into balance with the general principle of restraint by being deflected into a symmetrical path about the centre of the volume.

In the case of the sink from which water is flowing, the sidewise impulse is a component of the unbalanced radial force which in the average is being expressed towards the drain, and since the average effectiveness of this force in any one volume diminishes rapidly as the distance from the source increases, it follows that at some certain distance the general restraining forces will exactly offset the repeated impulses to tangential motion. At this stage there will be produced the symmetrical orbit; and, although its parts from moment to moment will be the products of ''absolute'' forces which are partly opposed, and although each deflection from straight-line movement requires, and therefore represents, an ''absolute'' use of energy, nevertheless, the complete cycle, when averaged and regarded as a whole, displays no tendency to expansion, and therefore represents no final measure of energy still unbalanced with regard to the point of withdrawal of matter, or negative focus of the unbalanced energy.

The sidewise force which ends in revolution is therefore a product of ''absolute'' Change, is intermittent, and is limited. After its first beginning this tangential force increases the average velocity of revolution up to a certain maximum. From that stage the revolution persists without change; but this movement is nevertheless the unrealized product of the repeated and ''absolute'' uses of energy, and is not, as some think, an inherited lineal translation which is being deflected unretarded into a curve by a single radial force. Because the beginning of sidewise movement leads automatically to expansion, there is, during the time this expansion is taking place, a steady reduction in the receipt of new sidewise energy. Finally, however, the stage arrives when the forces of restraint are sufficient to balance the average expansive forces of the normal straight-line motion, and then the balancing of the forces produces a repeating orbit, for no other path will represent this perfect equilibrium of opposed and repeated energies in different directions.

As we have noted in the case of the desk weight, revolutions cannot continue indefinitely in intersecting planes, for in these oppositions there will be early collisions and quick cancellations of the accumulated energies of such motions. The rapidity of the cancellations of these motions will depend chiefly upon the incompressibility of the fluid medium which floats the objects, and which urges them into their orbits; for these invisible currents must continue to revolve if the orbital motions are to persist. Only fluid-planes approximately parallel will escape the direct opposition of the unbalanced energies in other fluid-planes; hence only the motions in parallel planes can escape quick cancellation in relatively dense fluids. They alone, therefore, can continue through appreciable time and distances. Especially is this true of the artificially induced revolution that we see in the desk weight, for the energy of this revolution is given once only. Here the invisible fluid is a relatively incompressible water; hence all the planes of revolution except those which are almost parallel cancel each other quickly.

Continued orbital movements in the desk weight are possible, then, in certain paths only. In the case of the solar system, however, the planets are floated around the sun, not by one violent shaking, but by repeated forces, and through the blows of an invisible fluid relatively diffuse and compressible. For these reasons the planes of revolution in the solar system may and do vary perceptibly from perfect parallelism.

The sun and its planets, moreover, occupy but a small part of the universal sphere of Evolution. There are also tendencies to revolutions in immense universal orbits. These impulses towards far-away points affect to some extent the solar orbits. Under these exterior influences the solar system itself doubtless revolves in an orbit, being urged about some distant and perhaps universal focus of Evolution. These universal forces, however, acting as they do in relation to a focal point enormously distant, have the effect of practically parallel lines of unbalanced energy. They therefore affect the balance and symmetry of the planetary orbits in the same general way that a sidewise breeze would affect the orbits of objects floating in a water whirlpool. They thus transform the otherwise practically circular paths into ellipses.

The fact that orbits in general lie in parallel planes is confirmed by astronomical observations. We are told that about thirty-five billion stars compose the universe, but within twenty degrees of the plane of the milky way ninety-five per cent. of the stars reside, and in the polar regions (that is between forty degrees and ninety degrees of latitude), there are fewer than one per cent. The stellar mass is disc-shaped.

Professor Brownell speaks of the universe as being like a "cosmic grindstone."[1] He then remarks:

> Kapteyn found two great streams of stars. An order of a sort, not random motion, and selective distribution is evident even in the world of stars; and a system of an enormous kind dominates this largest aggregate of matter. The disc of our galaxy has a general structure. It has a process of its own. The grindstone works.

The sun is 25,000,000,000,000 miles from its nearest neighbour star, yet there are 600,000,000,000,000,000,000 electrons in one gram of matter. This comparison gives one an idea of the density of matter in the one spot, and the diffuseness in another.

One may read in the *Encyclopædia Britannica* that an ellipse is "the oblique projection of a circle", but then the incorrect assertion is made that the ellipse "is the orbit of a particle moving under the influence of a central force which varies inversely as the square of the distance of this particle." This last statement may be confirmed by the calculus, and it is usually believed that this mathematical confirmation proves its truth, but, as we have already discovered, this exact correspondence of a supposed truth with the findings of the calculus is itself sufficient proof that the principle is somewhat unsound. We need to remind ourselves of this now that scientists are attempting to use the mathematical formulas to interpret results under conditions where the opposed forces are balanced with such perfection (as at the perihelion point of planetary orbits) that the unit influence (that which has been discarded from the formulas) will have the decisive effect. The calculus is useless in such cases, and reliance upon it inevitably leads to error of opinion.

Thus we observe in general how it is that the balancings of the repeated sidewise impulses with the general forces of restraint inevitably develop repeating orbits, and we see also that these orbital impulses would soon take the form of circles unless there were more than one centre of Evolution.

If, therefore, a dense body should move into the solar energy-current from the outside at a speed, let us say, of sixty miles a second, one of two things must happen: Either it will pass out soon from the influence of the sun probably never to return, or else it will be so affected as to remain a solar planet. In the latter case, its incoming velocity will be reduced soon to an average speed normal for planets of the sun with this structure and at this mean distance—to a velocity, that is, where the surrounding energy-currents (such as they are) may float it and impel it at this average speed, and where it does not operate against the energy-component of its fluid environment. Indeed, except for the relatively powerful influence of an exterior focus of Evolution, this visitor would soon be moving, not in an elliptical but in a circular path. We have seen this principle illustrated in the desk set, and have observed that whatever the speed or angle of entrance of the injected flake its orbit will soon become circular. Except when moving in a path conforming with the energy-equilibrium of its environment, the matter coming from the outside will receive more energy of motion from one direction than another. According to this principle, its own excess energy of motion in the direction of its entering path will soon be absorbed by this excess energy from certain directions. For his reason, the entering matter, after a number of revolutions in which its own energy of motion is expressed in an unsymmetrical path, will find itself in an orbit exactly similar to that of the unbalanced energy-component of the fluid which surrounds it.

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[1] Baker Brownell: *The New Universe,* pp. 39–41.

In the sidereal system there is more than one important centre of Evolution, hence more than one focus of repeating sidewise forces. For this reason it is impossible that all the sidewise forces should be deflected into the arcs of perfect circles. The solar orbits cannot be uniform. Even if a circular orbit were begun by the use of artificial forces, it would soon be transformed into an oval by the impulses of the ''absolute'' forces which act with varying amounts of energy in different parts of the cycle. The energy-balance of all the motions of the particles composing the invisible fluid moving about the sun does not itself move in a path displaying perfect circularity.

Those who admit the reality of these repeatedly expressed forces of revolution and of concentration about different foci, can perhaps accept this reasoning and explanation, but those who regard planetary motions as the product of continuous sidewise velocity inherited from the past, acted upon by a single continuous radial force, and who use the calculus to prove the soundness of their theories, will be forced to deny these conclusions. Yet, one who accepts our premises, and who reasons from them, is able to affirm that the fact that the orbits are oval is sufficient proof that there is more than one focus of the Evolution which (negatively) impels the planets into sidewise motion.

The mean velocity of revolution, then, is the product of that average amount of sidewise force inducing revolution, which, at this mean distance from the centre, can accumulate without being cancelled. When, however, the greatest possible mean velocity has been attained (because further average accumulations of uncancelled tangential force are impossible), the path of the planet will then be a balanced and repeating cycle, and during each cycle all the repeated sidewise impulses against the planetary body will be completely offset by the equal and also accumulating resistances to sidewise motion. The planet will end the cycle with neither more nor less tangential energy than it had at the beginning. And, because at a certain distance from the centre of Evolution the tangential forces (as well as those resisting expansion) are (when averaged) regularly and consistently received, the planet, when it has reached (as it soon will) the inevitable state of balance with the average influence of its environment, must have a symmetrical and repeating orbit. Whether or not the orbit is circular or elliptical, however, the forces that deflect the planet through each cycle do fully offset and cancel those tangential impulses which if unresisted would tend to increase the mean velocity of revolution. In the elliptical orbit, to be sure, this principle relates only to the average state of affairs, for during one-half of its cycle the planet is being accelerated by the far-away gravitational source of unbalanced energy, while in the other half it is being equally retarded by the same force. The principle would relate, however, from moment to moment to all of a circular orbit—if any exist.

A very dense planet receives no more sidewise force from the orbit-making energy-currents than one much less dense, for both receive the full brunt of the energy-flow. Likewise a wall of earth receives as much force from the wind as a wall of thick steel. If, however, two planets of equal volumes have different densities and masses, more force must be expressed (or equal forces must be expressed longer) against the heavier mass to give it a certain velocity. Yet, since the sidewise impulses of the energy-current are repeated indefinitely, the two planets of unequal mass-volumes would, if unopposed and unretarded by deflections, finally accumulate equal velocities—the average velocity, that is of the energy-current about it. And when the heavier planet has reached a state of equilibrium with all the forces acting upon it, and is maintaining a certain mean orbital velocity, it is then receiving (moment by moment) the same sidewise force that a lighter planet would receive if it were at the same distance from the sun. The heavier planet, however, is deflected less (moment by moment) by the concentrating forces that it receives, for a certain amount of force will deflect a heavy mass less than a lighter one during a certain length of time. For this reason the curve of the heavier planet tends to be flatter, and its mean distance from the focus tends to be greater; and because the tangential force is less at the greater distance, the velocity of revolution in the more extended orbit is also less. We observe, therefore, that the mean distances of the planets from the sun are partly regulated by their volume-densities.

The details of the many forces that act upon the planet are complicated, and we shall not attempt to discuss them. Let us be sure, however, that the explanation of the repeating orbits does flow from the hypothesis of a material Evolution in a corpuscular pool of pressure. And let us try also to develop Kepler's third law directly from this theory.

There can be no reasonable doubt that the tangential force which acts against the planet is really a component of the force of concentration towards the drain in the solar pool.

This is proved by the fact that the tangential impulse is reversible in relation to this drain, and to it alone. The revolution may proceed clockwise or anti-clockwise, the result depending entirely upon the way the motion begins. This can be tried out with water in any sink. In whatever direction this motion is started about the drain, the velocity builds up until the maximum is attained. This fact proves that the focus of the unbalanced measure of forces from which the rotation in the sink springs, is at the centre of the drain. There it originates as a negative or reduced energy-volume inside an energy-pool. The revolution begins only when the water starts to run into the drain; and it is balanced around this point.

The orbital motion can be due only to an energy-influence originating (in the average) at the focal point of the motion in question, for a motion cannot start in a direction opposed to the lines of unbalanced force that gives the motion. The centre of a circle, however, is the only point of influence which tangential motions do not partly oppose. The drain of the sink, therefore, must be the point where the force of revolution originates.

What if we supposed that the unbalanced force causing revolution was directed towards a point outside the orbit? In such case there could be movement only in the direction of that point, and this motion could not be continued symmetrically about another focus. If, however, there should be relatively weak impulses towards some very distant exterior point (as we have noted when the log in the whirlpool is blown sidewise by a breeze), as well as the stronger force impelling an object about a local focal point, then the direction of the focal point of the component of all the unbalanced forces acting upon the object, changes from moment to moment. At any one moment it is, of course, the component in expression and direction of all the unbalanced forces then acting upon the object. In the example of the log in the pool, however, there are three active and repeated influences: the forces of resistance to expansion, the tangential components of the forces acting towards the local center of Evolution, and finally the forces acting towards the distant exterior point towards which the breeze is blowing. The first two of these forces, if left to themselves, would finally produce a balanced or circular orbit, for they would attain a balance in relation to this fixed centre of unbalanced motion—the centre of Evolution, from which (in a negative sense) all this unbalanced tangential movement springs.

We may think of these two forces, then, if left alone, as combining into a symmetrical or circular force. According to assumption, however, the circular force is constantly being acted upon by this third force of the sidewise breeze—a force acting repeatedly towards a relatively fixed and distant point. For this reason the position of the centre of revolution cannot remain constantly at one spot. Nor can it be the centre of that circle which averages the ellipse. Rather it is a point which itself unceasingly revolves. It has its own repeating oval orbit within the larger planetary orbit. This gives us a reason for the validity of the ancient description of orbits through the use of epicycles.

We need not worry, however, about such matters. Since the component direction of all the unbalanced forces constantly is located within the planetary orbit, and since the sidewise force towards the distant point tends to accelerate in one part of the orbit as much as to retard in another part, the repeating orbit is a symmetrical oval. In developing Kepler's third law, therefore, we can treat with the orbits in terms of averages—that is, we can take them as perfect circles with radii equalling the mean distances from the foci.

Referring, then, to a spherical energy-pool, we note *that only one of the molecules in each spherical layer* will move towards the centre of the pool when a unit of vacuum equalling the normal energy-volume of a molecule is created there, and that this molecule will move an average distance equalling the distance from centre to centre of contiguous molecules, and with a force which, as one time expressed, we shall call F. Yet, in whatever spherical layer the molecule may happen to be, its movement will leave a vacancy in that layer. Hence, after a proper interval, some other molecule in the next layer outside will move towards this same point an equal amount and with equal force. (F). Since, within the unit time in question, only one molecule of each of the series of spherical layers moves towards the point of the vacuum, the total force of concentration within unit time of the layers as a whole will also be F. When, however, we refer to any certain part of the layer, the average force-expression against that part only (during this unit time) will, as already noted, depend upon the ratio of the number of molecules in that part to the number in the whole layer. Now the fractional part of the force F which may within unit time be attributed to any one molecule in a spherical layer varies inversely as the square of the distance (R) from the centre (or as $1/R^2$), for this (assuming close packing) is the ratio that the one molecule bears to the entire number in that layer. When referring to a single molecule, therefore, the average concentrating force which will probably be expressed against it during any extended time may be formulated as the total number of force-impulses during that time (or as F) divided by R^2, or F/R^2. When, however, we refer to the circumference of the cross-section of a spherical layer, like the equator of the earth, the average concentrating force on this entire ring will be much larger than the average force expressed in reference to a single molecule. To find the average force expressed in reference to the ring, the force of F/R^2 must be multiplied by the number of molecules in the ring; and since the number of molecules in the ring varies in direct proportion to the radius of the circle, or as R, the force of concentration acting upon the spherical ring will vary as R multiplied by F/R^2 or as F/R. This law may readily be formulated for different spherical rings at different distances from the centre, by saying that F divided by F' equals R' divided by R.

We have already noted that a repeated use of the force F is required if a uniform velocity is to be maintained against the repeated resistances to tangential expansion, and as we have seen in an earlier chapter, such a use of force must be summarized according to the kinetic energy formula—that is to say, it varies directly as the square of the velocity to be maintained. Therefore F varies as V^2, and F' varies as $(V')^2$, and so we may state this mathematically by saying

$V^2/(V')^2$ equals F/F'. But since F/F' equals R'/R, it follows that $V^2/(V')^2$ equals R'/R.

Now the average time (t) of revolution in a balanced circular orbit equals the length of the orbit, or its circumference ($2\pi R$), divided by the average velocity (V). We may say, therefore, that t equals R/V; or V equals R/t. Also, V' equals R'/t'. Therefore, V^2 equals R^2/t^2, and $(V')^2$ equals $(R'^2/(t')^2$. Substituting these last values for V^2 and $(V')^2$ in the formula $V^2/(V')^2$ equals R'/R, we obtain the principle that R'/R equals (R^2) $(t')^2$ divided by $(R')^2$ (t^2). By simplifying this equation, we obtain the formula: $R^3/(R')^3$ equals $t^2/(t')^2$. This, when translated into unmathematical language, means that the time of revolution of an orbit squared varies in direct proportion to the cube of the mean distance from the centre. This is the discovered principle made famous by Kepler as his third law of planetary motion.

Naturally the belief in our theory is much strengthened by learning that both the law of gravitation and Kepler's third law of planetary motion may be derived from the principle exhibited by a spherical whirlpool of evaporation. In fact, we do not believe these laws would be true of any other arrangement of matter. Our theory of Evolution has presupposed a definite mechanical situation, as well as exact definitions of matter and mind, a necessary relationship between them, and a definite outcome from purposed activity. It supports the theory to learn that we can draw from it the formula for planetary orbits as discovered by Kepler. Indeed, unless some other mechanical situation can be suggested of which Kepler's third law would be equally valid, we seem to be justified in asserting that planetary orbits *are* created within a balanced mechanical and spherical energy-pool, certain volumes of which are being unbalanced by the Evolution of mechanical inertia. This confirms us in our hypothesis that Evolution is uneven, that there is a vortex of Evolution, and that there is an external and concentrating power which holds the universe within finite bounds by "absolute" force.

The second law of Kepler reads: The radius-vector, or line drawn from any planet to the sun, describes equal areas in equal times. Can this law, too, be derived from the spherical energy-pool concept? The second law does not mean that radius-vectors of two different planets describe equal areas in equal times, but refers to the orbit of any one planet.

If all orbits were perfectly circular, balanced, and with uniform velocities throughout, Kepler's second law would not be significant; but the orbits are elliptical, and the velocities are greater when the planets are closer to the sun. The earth moves faster at the time when its radius-vector is shorter; and the increased velocity might naturally compensate somewhat for the shorter length of sweep of the imaginary string which attaches it to the sun; but why should this compensation be such that the string always sweeps equal areas in equal times? Does the mathematic of the whirlpool explain this fact?

According to the theory, the orbital motion is not due to inherited lineal velocity compounded with radial force acting at a distance from sun to earth, but the earth moves in its orbit because it is impelled in this path by the component of unbalanced force of the exterior current, which component is itself spiralling around a vortex of evaporation. If the pool were infinite there would be no universal centre, and there could be no general vortex of evaporation. Nor could there be concentrations about certain vortices. But, when infinity is postulated, reason must retire, for all means of grasping relationships vanish. If, however, the pool be finite, there will be limiting bounds, there will be a universal centre, and there also will be unusual vortices of disappearance in those volumes where matter is more dense than normal. Whether energy-pool-impulsion or gravitational attraction be the nature of the force holding the planet in its orbit, if it is admitted that the universe is finite, then there will be more than one focus for the forces acting upon the planet, for there will be more than one vortex of evaporation influencing it. The path of a planet around the sun cannot be circular, therefore, unless the plane of its orbit happens to be perpendicular to the energies of motions of the particles impelling it in the universal stream. Furthermore, because the solar system is itself revolving about the universal centre, it is impossible for the plane of the planet's orbit (its ecliptic) to remain perpendicular to the average unbalanced blows of the universal stream. This may be the reason why the orbits of all the planets are slightly oval. The plane which would give a perfectly circular orbit should closely approximate the ecliptic of Neptune, for it is farthest from the sun and its orbit is almost circular. The plane of the orbit of Mercury cuts the ecliptic of Neptune at the greatest angle—approximately seven degrees—and the path of Mercury is the most oval of all the planets. The fact that both the eccentricity and inclination of Mercury are more than double those of any other planet lends some support to the theory that eccentricity is altogether due to the influence of the far away centre of the universal Evolution; but, in order to prove this, rather complicated calculations are required involving the masses and distances of the various planets.

Let us assume that the universal centre of force has an influence on planetary orbits, and even makes them oval instead of circular, and that the amount of flatness depends upon three factors, the mass-volume of the planet, its average velocity, and the angle of its plane to the universal influence. Does this assumption give us Kepler's second law of planetary motions? If it does, does it not prove that except for this universal influence the orbits of all the planets would be circular (or circular-spiral, if I may use such a term) rather than oval (or oval-spiral)? If this could be demonstrated we should have strengthened the argument.

If the earth moves faster in one part of its orbit merely because at that point it is being driven by the influences of two energy-currents acting together (whether the forces are impulsions or attractions), it will at that time speed up both in its concentration and in its side-slip. At that moment it will act as if it had been placed in a single energy-pool of evaporation with a greater "suck" at the centre and therefore with greater tangential side-slip. It would move in closer to the sun, and would move faster sidewise. The energy of side-slip, as we have learned, varies inversely as the radius. But, when energy does give motion to a body against resistances, the distance traversed in a certain time is proportional to the amount of energy expended. The velocity of the earth in its orbit, therefore, is roughly proportional to the energy of side-slip which at that time obtains. And if there were no cross-breeze of energy, the orbit of the earth would be circular, and the earth's velocity would be uniform. The cross breeze, however, impels the earth directly towards the sun on one side of its orbit, and at the same time increases its orbital velocity. The orbital velocity increases in a direct proportion to this additional force of concentration on the sun, whereas the radial distance decreases proportionately. The orbital distance traversed by the earth during a second varies therefore in direct proportion to the concentrating force at that time effective, whereas the distance from the sun varies inversely as this same force. The orbital distance traversed in a second therefore increases as much as the radial distance decreases. Hence, the product of the orbital distance by the radial distance remain always the same quantity, and this fact signifies that the area described by the radius-vector is a constant. We thus obtain Kepler's second law of planetary motion from the hypothesis that orbits, gravitations, cohesions, and so on, all appear as force-expression in a spherical and finite energy-pool of evolution. The irregular curves are caused by uneven evolution. There is more than one focus of influence. Thus the force acting upon the earth varies in different parts of its orbit, lessening in those places where the universal influence is impelling the earth in general away from the sun, and increasing in the opposite path of the orbit. In the next chapter we shall consider this gravitational hypothesis a little further.

CHAPTER XXVIII

EXPLAINING THE TIDES IN TERMS OF THE CORPUSCULAR THEORY

> The concept of circularity was sufficient to Aristotle to define the movement of heavenly bodies. But, even with the more accurate concept of elliptical forms, Kepler did not think he had accounted for the movements of planets.
>
> H. Bergson.

Gravity tends to concentrate structure—but, in the average, not indefinitely. Thus the rain, because it is urged by gravity, falls into the ocean, but at the surface of the water the downward motion is quickly compensated. In the ocean, the water experiences a persistingly perfect equilibrium of forces.

The force of gravity acting downward at the earth's surface may be given approximately as the energy required to raise bodies from a fluid energy-medium in which they are in balance into an environment less dense than that with which they are in balance. Or, in reverse, gravity may be measured as the energy which a dense body delivers when returning to an environment of its own average density after having been raised a certain distance out of it into a more diffuse environment. Yet gravitational forces, like all others, are intermittent, and this signifies that even when a perfect energy-equilibrium seems to have been established, this static stability is not as real as it seems. The state of average balance is maintained only by a repeating series of oscillations, or cycles of motion back and forth. Thus it may appear that bodies on the earth have no natural tendency to move towards or away from the centre of the earth so long as the surrounding environment has a density approximately equalling their own, but this quietude is never more than an appearance. There is always a cycle of movement through which the intermittent forces of gravity are being offset.

But there are perceptible gravitational cycles in which all the unbalanced energies compensate one another. They are not really different in principle from the oscillations of the book on the table, but they appear to be different, because, though created by similar forces, visible distances and appreciable periods of time are consumed in perfecting the average state of balance. The earth's orbit is such an extended but compensated energy-cycle of gravitational forces. Even though the compensation of the entire orbit is perfect, so far as we can judge (the beginning and ending being the same), we are commencing to understand that "absolute" force is required to create not only the curve of each inch of the path, but the path as a balanced whole. In all cycles' "absolute" and real energies in one direction are finally offset by the expressions of equally real and "absolute" energies in another direction.

Or, a life-force may itself create a cycle of movement which is independent of, and which to some extent overrules, mechanical nature, but this, too, is usually compensated in the end. Thus when an apple falls from a tree it delivers back to the environment the amount of energy once consumed in raising its substance above the ground.

Nevertheless, the unbalanced energy conventionally known as weight is normally evidenced on the surface of this earth only when some condition of density-balance is being restored that has previously been disturbed. The earth's force of gravity as expressed on its surface represents especially that tendency to unbalanced movement which is directed towards a volume wherein density, and therefore energy-expression, has been abnormally reduced from within. And since these gravitational concentrations tend towards the denser masses, the density of mass tends correspondingly to increase in the average as the centres of the denser mass-volumes are approached. Only the cohesiveness of structure (that is to say, its lack of perfect fluidity) prevents a steadily increasing density from surface of earth to its centre in the same fashion that the density of the air steadily increases from the higher altitude to the lower.

Gravity tends to come into evidence, therefore, whenever the natural order,—not of uniform but of gradually increasing densities,—is disturbed. If the parts of the earth should never be affected hereafter by unbalanced forces, if no winds blew them, nor varying temperatures acted upon them, nor tides affected them, and if there were no life-forces to create artificial disturbances in that harmony to which the structures of the earth in the average normally attain, then, so perfect would the equilibrium be, and so slow the evolution of matter, that the local phenomenon of gravity would be almost unknown to experience. Man now encounters gravitational forces principally because absolute Change, followed by adjustments, decomposes this harmony.

Let us consider, then, some of the accomplishments of gravity: The earth's orbit displays no average tendency to converge upon the sun yet the earth stays nearer the sun than would be the case if the sun had no local gravitational influence. Except for the sun's negative gravity-influence, the earth would probably take an orbit about the centre of the universal energy-pool. Yet, if we refer to the whole sun-earth-volume, we may say that the sun's influence is not able to draw the earth closer. Through a cycle of movement the earth and sun have arrived at the average density-equilibrium appropriate for them at this time as parts of the larger energy-pool. The general restraining forces balance through time and space the tendencies of earth and sun either to move farther apart or to come closer together. A pressure-balance between opposed "absolute" forces is thus established.

Nor is the force of gravity more effective in changing the average separation one from another of the parts of the elements composing the earth's volume than it is in changing the average distance from earth to sun. When one considers any complete energy-cycle, whether very minute or widely extended, it will seem to the casual view that nothing permanent is accomplished by the movement except the limitation of the theoretical unlimited separation of objects in the presence of unceasing motion. Yet even this represents a tremendous accomplishment, for by it we are provided with an environment in which Evolution becomes possible. For this reason every part of such a cycle stands for, and should therefore signify to us, the presence of a transcendent Power. The balancing of opposed and absolute forces into a symmetrical cycle of movement should therefore stand for almost anything but Conservation; and this is true whether the cycle is the imperceptible oscillation of a book on a table, or the orbit of Neptune which consumes 165 years of time and millions of miles of space in the balancing.

Whatever energy-volume we observe, therefore, so long as we do not look (in our mind's eye) either at the interior of the smallest bit of matter or at a universe as a whole,—so long, that is, as we do not think of the limiting extremes, or of those realms meeting the spiritual, but regard merely the conditions prevailing between extremes,—we discover that the repeated manifestations of gravity (or of its components) create the *average* density-relation arrangement which prevails, such as the average spacing of earth from sun, of moon from earth, and even the location of the water of the ocean upon the earth's surface. Gravitational force packs matter into layers which are normally ever denser as one approaches the centres of the bodies; and a component of gravity causes the revolutions of large and small planets in approximately balanced cycles. Yet, after a balance in density-volumes and motions has finally been attained in time and space, the local manifestation of gravity represents merely the restoration of those density-relationships which some non-uniform force has temporarily disturbed. None of this would be possible except that it occurred within the bounds of a restrained energy-pool of the universe.

The movement that re-establishes the local equilibrium may at times even be directed away from the centre of the earth. Water rises from the ocean into the sky under the influence of the sun's heat. It also crawls upward into the pores of a dry rag. And the molecules in the lower part of a pendant drop receive sufficient upward pressure to oppose, and even to overrule, gravity. At times, owing to the abnormal cohesiveness of certain structural formations, an equilibrium is maintained which is different from that which gravity alone calls for. Thus, when the water rises against gravity into the pores of a rag, it leaves the more diffuse environment for the denser, and by this snuggling into the shelter of the denser formation it obtains a better balance with the pressures of the environment. The dense and resistant atomic structures of the rag seem to be able to shield the water-molecules somewhat from the usual batterings, and this diverting of the unbalanced energy-stream makes the pressure from the direction of the rag less (for the time) than that from the water-molecules below. Hence some of the water is urged to climb upward.

Capillary ‘‘attractions’’ and the ‘‘skin tensions’’ of the pendant drop—both being phenomena which, up to a certain point, have the power to overrule the usual tendency of a dense body to move downward through fluid medium below it—are examples of a somewhat similar principle. They appear to illustrate the result of a relief from the usual pressure from one direction. Protection induces bodies to move closer to that which protects. A drop of water resting on a flat surface rounds up until it presents a curving convex top. It does not flatten down as one would expect if gravitation were the only exterior force affecting it. Thus it is proved that the unbalanced force of gravity is but a small part of the various forces affecting every object.

One type of capillary ‘‘attraction’’ seems to be a disguised form of the same force-principle that causes the water of the flowing river to move upstream behind the piers of a bridge. The piers do not attract the water just below them, but they protect it from the usual pressure of the downward flow of the river. The water moves uphill because it is pushed in this direction, and in this way an area of water higher than the surrounding current is created just below the piers.

It is known too, that water at its boiling point weighs a little more (there is therefore more gravitational action against it) than at freezing temperature. And there is the every day experience that common salt when put into water, will, as it dissolves, rise in the solution and thus the centre of gravity of the water and salt combined will be raised. There is also the phenomenon of osmosis, in which a fluid penetrates the pores of a thin membrane, forces itself into another fluid on the opposite side, and actually raises the level of the second fluid to a higher point than that of the fluid which does the penetrating. The gyroscope is a mechanism which defies gravity temporarily. The influence of a catalyst, also, which, by being present, causes chemical actions to take place, appear to illustrate the unbalancing effect of the shield of a dense structure. Even gravity, then, can be shielded or offset in certain ways—at least for certain durations and to certain extents. The piers of the bridge, however, do not resist the downward rush of the stream for ever, or with unlimited power. The unbalanced effect of this protection does not accumulate indefinitely. Nor can the pendant drop of water be increased in bulk indefinitely. At some point in time, or within some dimension in space, all these accumulating oppositions will submit to unbalanced force. At some stage the drop will divide and fall, the water behind the piers will stop accumulating. Even the piers will finally crumble away. The overruling of the law of progressive densities is not forever important.

Nor does density increase in a direct proportion to the atomic complexity of the elements. The symmetry of structure has some bearing on this relationship. Weight is not directly proportional to the number of parts in an atom. The atom with the most parts may monopolize a volume which is either larger or smaller than the atom of fewer parts. Thus the structure of the atoms of water and steam are identical, but their specific gravities are different. The "atomic number" of gold is 79, its atomic weight is 197.2 (a figure which is determined by its momentum when moving at certain speeds) and its specific gravity is approximately 19.3. Copper, on the other hand, has an atomic weight of 63.57 (32.3 per cent. of gold) and a specific gravity of 8.8 (45.6 per cent. of gold).

It should also be noted that the disintegration of complex structure radioactively indicates that through the ages there is an expansion of material formations and an acceleration of motions—the reverse, that is, of the concentration and congestion that an effective gravity theoretically calls for. This principle, however, is relatively unimportant, for it has no perceptible effect on the gravity which concerns us. Yet it might be well to emphasize the fact that the universe is submitting to a process which, as time passes, permits it to display less of the inertia of matter, and more of the imponderable power of the spiritual. Certainly, we can partly agree with Professor Whitehead when he says:

> The universe shows us two aspects: on one side it is physically wasting, on the other side it is spiritually ascending.
>
> It is thus passing with a slowness, inconceivable in our measure of time, to new creative conditions, amid which the physical world, as we at present know it, will be represented by a ripple barely to be distinguished from nonentity. The present type of order in the world has risen from an unimaginable past, and it will find its grave in an unimaginable future. There remain the inexhaustible realm of abstract forms, and creativity, with its shifting character ever determined afresh by its own creatures, and God, upon whose wisdom all forms of order depend.[1]

In his great work, *Philosophiæ Naturalis Principia Mathematica,* known as the *Principia,* Sir Isaac Newton asserted that the motions, shapes, and tides of the solar system could be explained as the results of the forces of gravity acting according to the inverse square law. He also proved (but he used a generalized mathematics to prove facts about a generalized situation) that the already accepted laws of Kepler followed from the general inverse square law of gravity.

Newton proved, it was thought, of the oval planetary orbits, of the orbital changes due to mutual planetary attractions, of the oblateness of all rotating planets, of the procession of the equinoxes, of these and many other phenomena, that they were produced by the force of gravity acting according to the inverse square law. Even though his mathematics and his mechanical concepts were somewhat faulty, these proofs have developed noticeable and important exceptions only during the last few years. In all the more generalized situations the gravity-formula of Newton has supplied answers so satisfying to the experimentalists that the idea of "attractions" has usually been accepted. Even now it is being questioned only in those specific cases where, evidently, practice does not conform. For the most part, however, the old principles are still regarded as exactly correct in their application to the larger relationships.

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[1] A. N. Whitehead: *Religion in the Making,* p. 160.

Even the tides are supposed to be due to the distant "attractions" of the sun and moon—particularly of the moon. Yet, the tides may be explained otherwise—and perhaps with more general consistency, and in simpler terms. Certainly, the present explanation is neither consistent nor simple.

In accord with the corpuscular theory we must naturally conclude that the tides are due, not to "attractions", but to the repeated receipts of unbalanced energy-movements from those matter-bodies which shove the earth around the sun. We differ with the classic theory also in that we assume that the forces causing both the orbital revolutions and the tides are repeatedly received in "absolute" fashion. They are "absolute" and discontinuous energies, and in this sense they cannot be explained in terms of Conservation. The motions thus created "absolutely" are later cancelled without mechanical compensations. Later they are renewed "absolutely" so that conditions approximately repeat themselves, but none of this can properly be regarded as examples of mechanical Conservation.

Those who regard the earth's orbit (or any other cycle) as balanced in the sense that no energy is consumed "absolutely" in creating it, look at the situation in a limited and even incorrect fashion. They consider the cycle in its entirety—when ended, and after the "absolute" accomplishment has been completed. Then they deny the "absoluteness" of the accomplishment. They arbitrarily average all of the unbalanced forces through time and space—and then, because the movement has lead back to the beginning, and to a repetition in kind, they view it as signifying and illustrating a condition in which there has been no real expenditure of energy. Yet there is no Conservation here. New and ''absolute'' energy has been required to form each inch of the bending orbit. All deflections, or reversals of straight-line motions, consume energy ''absolutely''. All orbits, to be sure, are finally thrown into repeating cycles, but only that the universe may not indefinitely expand—and in this accomplishment the power of a supreme Cause is revealed.

Quite different from the conventional belief, then, is the evolutionary, or corpuscular theory of gravity, for, according to it, the earth is intermittently, but repeatedly *pushed* around the sun. It is shoved from behind, and it is resisted in front. Its curving motion represents in the gross average the balance of movement created by partly opposed energies. The earth is mashed between forces which, within a full year, return the sorely driven planet back to its starting point. Inch by inch the different component of these forces deflect the earth, until finally it finds itself repeating its motion about the sun. And thus pushed and resisted, the earth is mashed somewhat flat. Its soft, fluid surface visibly and quickly yields to the opposition of forces—and thus the sun's tides are created. As the earth revolves, these depressions revolve also, but they always remain almost parallel to the line leading to the focus of orbital movement, for the opposed forces tend to squeeze the earth into planes of depression always parallel to this focal line.

The earth is strongly influenced by the unbalanced energy-currents which focus upon the closer moon. If the moon were held stationary while the earth floated freely, the earth would be urged into an orbit with the moon as its focus. It is the influence of this lunar current, then, an unbalanced energy-current which acts against the earth in a direction almost perpendicular to the direction-line leading from earth to moon, that causes the depressions of the lunar tides. And, correspondingly, the oceans *bulge* in the opposite directions —that is, along the line pointing almost directly towards the moon. And yet, because there are other currents of corpuscles revolving about other foci, the tidal protuberances are not exactly symmetrical with the line pointing towards the moon. There are also lags due to fluid frictions, but we shall not attempt to consider these matters here.

The flood tides, then, are the negative results. The ebbs of the ocean are caused positively—and they are products of forces which, though centring on the moon, point in a direction almost perpendicular to the line leading to the moon. Because we look at gravity in reverse, and regard it as due to a continuous force of attraction, we naturally interpret, or try to interpret, the tidal depressions in reverse. Yet, because our theory of attractions is unreal, our necessary deductions therefrom that the water of the ocean is positively induced by the ''attraction'' to *protrude in a direction away from the attraction,* is unreal also.

If a person positively squeezes a soft rubber ball between his hands, it will naturally project unusually on the free ends. Anyone can understand this phenomenon, but it is difficult to conceive how ''attraction'' towards a single point (and therefore affecting the earth in a single direction) can possibly create positively two equal and opposite projections of the ocean. We have never been able to understand either how the force of a single attraction, unless it had ''absolute'' power, or drained some unbalanced source of power, could create a perpetually repeating orbit or any amount of curved motion. We have never been able to understand repeatedly reversed motions in terms of Conservation. Largely because we have been unable to accept the conventional theories, we have attempted to develop the corpuscular or evolutionary hypothesis of gravity, and it now seems that this theory supplies us with a gratifyingly reasonable explanation of the tides.

According to the conventional hypothesis, the tide bulges away from the centre of the earth on the side farthest from the moon because the attraction of the moon positively pulls the earth away from the ocean—leaving the ocean up in the air, so to speak—whereas, on the other side, the ocean is supposed to be attracted away from the earth. It is believed that somehow the moon, though of relatively small mass, and at a great distance, is able to pull the earth away from the ocean with a force that more than counterbalances the force with which the earth tends to hold the ocean close to itself. This is considered possible even though the ocean bears down upon the surface of the earth with tremendous weight-force. The ocean is close to its centre of the earth's relatively enormous influence of attraction, and far from that of the moon. Yet this explanation of the tides has been accepted even when it is known that the average distance from the earth to the moon does not change, and when, therefore, the moon in the average does not really "pull" the earth anywhere—and certainly not away from the ocean. Certainly no one can claim that the attraction of the moon hauls the earth through space with such an acceleration that the ocean on the earth's surface cannot keep up with the movement, and that, for this reason, the ocean lags behind the earth's mass like the tail behind the speeding comet. If the earth were thus being accelerated, why shouldn't the fluid protuberance in front (towards the moon) work its way around to the rear and make a still bigger bulge there? As a matter of fact, the earth and the moon do not move towards each other, and the bulge of the tide is not in the right place to represent a lagging tail.

The conventional theory of the tides is incredible. Many years were required for ingenious theorists to account for them in this or in any way that physicists could regard as consistent with other theories. No one can develop in the laboratory a similar set of tidal bulges in a stationary ball of iron with a molten surface by revolving a single magnet around it. A single distant influence cannot develop opposed bulges in a sphere (even when the sphere is inside a generally balanced energy-pool) along the single line of the action. The lunar tides of the earth are easily accounted for under the corpuscular theory of gravity, however, because there are supposed to be the direct products of two forces acting in positive opposition that repeatedly squeeze the oceans with such unusual energy that they yield and take an unsymmetrical contour. A single "pulling" force acting in one direction cannot possibly create protuberances in a body identical with those that will follow from the application against it of two opposed and mashing forces! A soft ball can neither be pushed nor pulled from one side so as to create in it the contour that it would receive if mashed between two hands.

But perhaps the conventional physicists will claim that "centrifugal" force acts in opposition to gravity. They may urge that if the earth were whirling about the moon, and if the centrifugal force (whatever such a force may be, and whatever its source) were stronger than the moon's attraction, the ocean would bulge away from the moon. Even in this case the contour of the ocean closest to the moon would be reduced below its present tidal protuberance by the same centrifugal force-action, and we should suppose that it would end as a depression rather than as a bulge. If centrifugal force were really such an influence, why doesn't the ocean accumulate on one side of the earth? If one should swing a wet ball about his head, he might expect the surface water to accumulate on the far side. Certainly one would never find a hump in the soft fluid surface in the direction of the centre of rotation equalling the hump on the far side. But why talk of such possibilities in connection with the lunar tides, for the earth does not swing around the moon. The moon encircles the earth while moving in the sun's gravitational field, hence no centrifugal force acts in respect of the earth that could possibly account for the tidal bulges.

The unreality of the conventional theories of the tides harks back, as has been indicated, to the hypothesis that orbital motions are due to an inherited velocity in a mass which is being acted upon by a single force of attraction. This explanation of orbits is especially unsound in its assumption that the force of attraction need display no measure of "absolute" energy during its process of orbit-making. We must of course admit (or we must do so, at least, if we believe the axioms of conventional mechanics) that if the mean distance of the moon from the earth remains constant, the action of gravity between the moon and earth does not create motion along this particular radial direction-line. This, however, does not mean that real energy is not consumed in the transformation of straight-line motion into a repeating cycle of motion. Every such deflection does consume real energy—even according to conventional mechanics. Yet, today, the orbits of the electrons in the atoms are not usually supposed either to discharge or receive energy excepting at the mysterious intervals when the mean radius of the orbit is being lengthened or shortened, more or less permanently, instantaneously, and, it is claimed, without cause. This view seems most incorrect. Nor, as we have said, is the situation improved much by adopting the theory of Schrödinger, who, at variance with the concept of Bohr, regards the atom as static in structure, but with mysterious changes in the location of its electric charges.

Gravity displays no more ''absolute'' force, so runs the old belief, in the deflected motions of the earth than it does in the unperceived oscillations of the book on the desk. If energy were present in either these short or long cycles which are finally balanced, says the scientists, conventional physics would require revamping from its centre out. And we are making just this claim. We contend that because ''absolute'' energy is consumed in every such manifestation, in every deflected or reversed motion, physics does need a thorough revamping.

We assert, then, for more than one reason, that the tides cannot be derived from the force of gravity as conventionally defined, but must be attributed to ''absolute'' and partly opposed sources of unbalanced energy within a grossly balanced energy-pool. We may still call one of these force-principles ''gravity'', if we like, but it cannot be regarded as a force acting on the earth in the direction of the moon, nor can it be thought of as an energy subscribing to the doctrine of Conservation.

If the earth were pulled through the air faster and faster by a string leading toward the moon, and attached to the nearest ocean only, there could be bulges front and rear in somewhat the same fashion that the tides bulge. If, therefore, the gravitational influence of the moon were due to continued acceleration of this type (a force somewhat similar to that suggested by Einstein as the cause of gravitational force) one could conceive of projecting tides. These hypotheses, however, as already stated, are absurd. There is no continued movement of the earth toward the moon, and there is no force pulling the front ocean rigidly and separately ahead, and no force keeping the oceans apart. In our illustration the front ocean, unless it was rigidly attached, would pull away from the earth altogether.

The earth and the moon steadily retain their relative positions; and the balance of the forces acting against them is sufficient to cause continual orbital movements, but not radial accelerations. The two opposite bulgings of the tides cannot be explained, therefore, except on the theory that the earth is constantly being compressed between repeated forces which, in the average, are sufficiently perpendicular to the radius vector leading from earth to moon to cause the orbital movement also. This, too, conforms with our theory of orbits.

Astronomers assume that the earth's motion must be slowing down sufficiently to account for the tidal frictions—which they claim, also, have effects too small to be noticeable. They must make some such claim as this or else the Conservation doctrine falls. They assert, however, that the retarding effect is so slight that the period of rotation is not increasing from this cause more than one second in 500,000 years. We on the other hand, who deny Conservation, can believe that the energy of the tides is ''absolute'', and that it represents a component of an energy of motion added to the universe with the view of some final accomplishment.

Yet, after all, the energy of the tides is no more real than that consumed day after day by the columns of a building while supporting its load. Nor is it more real than the energy repeatedly manifested in the so-called thermal oscillations.

The astronomer of to-day is obliged to accept such an unsatisfactory explanation of tidal energies as the following statement provides:

> When the periods are unequal so that the tides move around the rotating body, some energy is changed to heat by friction. This energy comes from the kinetic and potential energies of the system; and takes place in

> such a way that the total amount of momentum of the system remains unchanged.[1]

The tides, of course, are influenced somewhat by the earth's rotation, and in a sense the earth's rotation on its own axis is influenced by the tides. According to the corpuscular theory, every motion of the earth as a whole and of its parts is due to unbalanced energy received from the outside. The push-effect is made possible by the presence of a general energy-pool ''absolutely'' maintained in average orderly restrained motions of parts. It is, therefore, natural to suppose that a body subjected to the temporarily uncompensated pressures which create these liquid protuberances should be affected in some other fashion by these unbalanced forces. As the earth revolves on her axis from west to east, the tides move over the earth's surface from east to west, so it might almost be said that the earth revolves in spite of the tides. The moon may be the indirect cause, therefore, not only of the major part of the tides, but of the earth's rotation as well. But axial rotations present another puzzling relationship. The earth now rotates relatively rapidly on her axis whereas the moon rotates just enough to keep one side forever facing the earth. What is the explanation of this?

No active cause of planetary axial rotations has been identified. In fact astronomers deny that there is a present cause. They say that the planets rotate with inherited velocities—that is, from a cause that once existed but which no longer operates. Both the rotations and revolutions of the planets are regarded as mere perpetuations—the remnants of the power of a cause which has not yet been cancelled. While it is probable, they think, that the planetary motions are now being reduced by frictions, no general ''absolute'' cause can renew them. The motions of the planets to-day have potential energy only—like that of moving cannon balls. When these inert worlds have finally been brought to rest they will perhaps never again be started, they say, unless somehow the energy generated by the retarding frictions appears in new motions. Only this solution is offered by the astronomers —and yet it is unsatisfactory.

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[1] F. R. Moulton: *Introduction to Astronomy*, p. 454.

How can one possibly justify the belief that energies of rotation and revolution (if really inherited) have not suffered sufficient resistance during the millennia since the earth was created to have been cancelled before this? Indeed, the tangential motion is completely cancelled and reversed during each one-half of a single orbital cycle. And even if one is willing to accept this inconceivable statement on the basis of pure animal faith (as Professor Santayana would term it), how, then, may the fact be explained that the moon rotates just often enough to keep her face constantly towards the earth?

Both the period of the moon's axial rotation and her orbital period are changing, it is supposed, and there is no reason that these two motions should have constantly changed simultaneously since the beginning of time. If the orbital energies were really inherited, why should the times of rotation and revolution be maintained in a constant ratio?

Some of the astronomers have advanced ingenious explanations of the moon's failure to expose more than one face to the earth observer; but, as Professor Moulton frankly says:

> The most striking thing in the earth-moon system is that the moon's periods of rotation and revolution are equal. It is extremely improbable that this unique relation is accidental. . . . The moon's periods of rotation and revolution are both increasing, and it is infinitely improbable that all the factors on which these effects depend are so related that they are exactly equal. Even if they were equal at one time, they would become unequal with a changed distance of the moon from the earth. That is, the present is not a fixed state of equilibrium, and the consideration of the tides does not remove the difficulties. It seems probable from this line of thought that some influence so far not considered has caused the moon always to present the same face towards the earth.[1]

In another paragraph Professor Moulton remarks: "It seems probable that the earth and moon are connected by forces not yet understood.'' This problem of identifying these unknown forces is no more important than the problem of identifying the cause of the earth's axial rotation and of her orbital revolution. If the moon is compelled to rotate by forces connecting the earth and moon in a fashion not understood, why may we not suppose that the movements of the earth represent the presence of forces now active in solar spaces, but not yet realized?

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[1] F. R. Moulton: *Introduction to Astronomy*, pp. 456–8.

The unbalanced effects of Evolution display a persistent rotary force-component, an expression of rotary motion around the sun always in one direction, yet a motion constantly deflected, finally reversed, and therefore representing unbalanced energy that is being steadily absorbed. At a certain speed (and within a certain gross or average time) the forces inducing rotation are cancelled as received—and the same thing may be said of the earth's axial rotation.

Some repeated measure of unbalanced force, therefore, must cause the earth's daily rotation—some force-action whose source lies inside the perimeter of the gravitational orbit. Certainly, the earth's repeated rotation in twenty-four hours is not due entirely to unconsumed inherited influences. Nor is it possible that the earth's annual revolutions about the sun are due entirely to inherited energies. The sun also rotates on its axis. Mars rotates in a day of twenty-four hours and thirty-seven minutes. Enormous Jupiter rotates with immense surface speed, the period of rotation being only nine hours and fifty-five minutes, whereas Saturn, next beyond, with somewhat less mass than Jupiter, has a day of ten hours and fifteen minutes.

The axial rotation of Jupiter, moreover, like that of Saturn, and of the gaseous sun, is not uniform throughout the mass. The equatorial belt rotates in a shorter period than the higher latitudes. This phenomenon cannot be explained on the assumption that the rotation of the planets on their axis is due to inherited motion. Forces must act in the present with real energies to cause these variable rotary speeds in different parts of the same planet. The frictions between the different sections of the sun and of Jupiter, as they revolve at different speeds, must be enormous; and it is incredible that they should be inheritances from an indefinite past.

With regard to the problem of the different periods of rotation of different parts of the sun, Professor Moulton has this to say:

> The reason that the sun rotates in its peculiar manner is not certainly known, though Elliott Smith has attempted to show that the more rapid rotation of the equatorial zone is an inevitable consequence of the contraction of a rotating mass of gas. The question deserves further quantative examination.[1]

Again:

> According to this view the outermost cylinder, which includes only the equatorial zone, rotates fastest, and successive cylinders towards the axis rotate more and more slowly. It is supposed that this condition is inherited from some primitive state and that friction has not yet reduced the rotation to uniformity.[2]

Professor Moulton then remarks that the author of this theory neglected the "Convection currents which must certainly exist to great depths, and which would quickly destroy the supposed different rotations in different cylinders", and then adds: "Notwithstanding these difficulties, no other theory at present is more satisfactory than that the sun's peculiar rotation has been inherited from more extreme conditions which prevailed in the remote past."

We perceive, therefore, that the scientist has no acceptable theory of axial rotations, and no intelligible explanation of the varying periods of axial rotations within the same body. He can no more explain these phenomena than he can account for the power of gravity, or for orbital revolutions. How, indeed, can we expect him to explain these matters in terms of his mechanistic premise? How can he possibly interpret the manifestations of an "absolute" force in terms of a postulate of Conservation which by its very terms denies

[1] *Ibid.*, p. 389.
[2] *Ibid.*, p. 390.

the possibility that "absolute" force might be real? Nor does his mathematics help the physicist in this dilemma. On the contrary, by being unreally conceived, this partly abstract science helps to support his faith in his mechanical axioms. The physicists uses an incorrect numerical formula to prove an incorrect philosophy, and to demonstrate an unreal and even irrational set of conditions and causes.

The scientist is involved in a confusion of hopelessly erroneous assumptions which he must abandon before he can possibly advance satisfactory explanations. Not even the attempt to introduce Time as a causative force (a force which some dream of as being non-mechanical), and to immerse events in a flux possessing in its flow a momentum capable of introducing spontaneous Change,—or, perhaps, Change as a more or less natural offshoot of Time itself,—is helpful as an explanation, or sound as a hypothesis. This recent suggestion gives us no intelligible ideas—it really adds to our confusion.

The idea of a time-change as a causative principle in mechanics is just as inconceivable as is the concept of "spontaneous" change. "Spontaneous" change cannot occur even in a flow having momentum, or with the semi-spiritual *élan vital,* or directioning, that M. Bergson postulates, for if the flow has momentum, then the momentum itself would cause the change, and the change would not be "spontaneous", nor would it be time-caused. And yet if the momentum as it creates the change of events of to-day is mechanical in its definition, then the change will be mechanically grounded, will be mechanically determined, and will have no more spiritual significance than can be attributed to the power behind the initial shove ages ago. Since the beginning, according to such a philosophy of momentum-directioning, every act is part of a mechanical sequence, and we now move this way instead of that because we were once shoved at least partly in this direction by an "absolute" force—by the only force, that is that now exists, that can ever exist, and, therefore, that can now cause change and life.

But, on the other hand, if there is no momentum, there can be no joined-up mechanical flow; and hence the changes appearing in matter (a substance which, if left to itself, would always average the same) are not only disconnected, disassociated, and uncreated, but are also quite mysterious, even mentally inconceivable. The new forms from day to day appearing in mechanical realms where actions and reactions are supposed to be equal, have no cause—either mechanical or spiritual. If, therefore, we should subscribe to the mechanical postulates of Mr. Bertrand Russell, and if we ascribe all mechanical events to a purely mechanical relationship which involve no spiritually given momenta, and no present "absolute" spiritual source of the average motions of matter, we should be obliged to accept his conclusions that there is no causal chain connecting events.

These "essences", as Professor Santayana (who to some extent agrees with Mr. Russell) calls the sense-data, or appearances, which he regards as altogether fortuitous, are not only infinite in number, but since they have no cause they must be the creations of pure chance. Since they happen accidentally, even haphazardly, and since they are not purposefully created, they cannot be thrown into a system. No law connects them, hence their coming can neither be predicted, explained, nor formulated.

Modern thinkers offer us almost incredibly materialistic descriptions of life. One school suggests, as we see, that mechanism is influenced by a spiritually given momentum, an influence still being derived from a spiritual cause that acted in an indefinite past; while a second school claims that mechanical events are enforced by Time while being presided over by Chance. Yet, whether there be this momentum from the indefinite spiritual past, or whether there be none, whether the shrapnel explodes while moving in a once mentally ordained direction so that the motion of its exploded parts still partake of the original aim, or whether it now bursts at random while standing still, shedding its parts indiscriminately through space, both schools conceive (or, at least, this is the implication of their theories) that Time is the creator of Change—and even of events. They seem willing to think this because Change appears *during* the passage of Time when conceived as a whole duration. They do not even conceive that mechanical unit events, the building-blocks of mechanical Change, do not even consume any of this time. Nor does either school identify the power that now makes the shrapnel explode into Change. Hence, neither defines the real Cause of Change. Yet it is incredible that mechanical momentum should persist with full force in a situation notable especially for its reversed motions.

Oswald Spengler, the German philosopher, sees history as a mechanically repeating rhythm, so he, too, regards Time almost as a causative agent. Mr. Wyndham Lewis, in *Time and Western Man,* vigorously attacks the mystical, emotional, and, as he terms them, childlike concepts that have been developed in attempts to explain the changing life-experiences without doing damage to the mechanically explained world. He sharply criticizes M. Bergson, the father of the band of Time-worshippers, who was himself influenced by Darwin's theory of an Evolution taking place *in* Time, as a whole—although the mutations themselves appeared to be instantaneous. He also takes to task others, such as Alexander, Bradley, and William James, who, in some respects, follow Bergson rather closely. Nor does he fail to object—in rather general terms, it is true—to the hypothesis of Einstein who assumes that it is proper to add a variable Time to the Newtonian formulas as a principle capable of causing mechanical change.

His criticism is sound so far as it goes, for the Relativity additions represent an attempt to make pure mechanics interpret events displaying the influences of forces lying quite outside mechanics. And we have no reason to suppose that Time itself participates in the unit mechanical phenomena.

Professors Whitehead, Russell, and Eddington are all disciples of Einstein, and they (Professor Whitehead especially) are trying to paint a picture of an active, even virile, Cause on a canvas which, if it were only as they at times regard it, would be completely lifeless and mechanistic. First, however, they ingeniously drape the background of their concepts with illusive veilings of events created within duration as a whole, events which they credit to Time's own power. Indeed, they have created even in the midst of pure mechanism

—or, at least, with characters purely material—such a hazy, wavering, mysteriously glimmering and grossly viewed object, that they have almost convinced themselves that Time alone, rather than the unexplained power behind the cyclical mechanical motions, has given it life and change. In truth, however, they have described only that which is purely materialistic and without power of causation, but they have viewed events so grossly that they include both the instantaneous Change and the time-spread period of no mechanical reality. And, moreover, the really "absolute" Power which creates anew from moment to moment the active motions of the sun and wind, and which gives all the life and charm to this scene, is not only unexplained, but is usually denied.

The astronomers, too, insist on relegating the cause of life, and of the more or less cyclical movements of the physical world, solely to the influence of a power which once operated, which no longer operates except as an inheritance, and whose indirect influences, still persisting through a purely mechanical series of events, even prescribes to some extent the mechanical events of to-day. The earth's motion about the sun is thus explained. We cannot subscribe to this view. We cannot agree in any important sense with those who refuse to ascribe the slightest power to any mental Cause of motion acting in the present, and who thus not only deny that there is present purpose or plan in happenings, but who virtually deny their own independent mental powers, and the unmechanical qualities of their own minds.

Not that these writers admit that their disguised mechanistic doctrines mean what is here indicated. They try to preserve a place for a spiritual character in their scheme at the very time that they virtually deny power over the mechanical to any spiritual Cause. Few of this school will even admit the presence of a directional momentum such as M. Bergson calls for in his mystical religio-mechanism. If, however, mechanism has no external Cause, then, unless Time itself is a Power that should properly be capitalized, either the mechanistic procession or flow must have momentum stored in it—and thus a prescribed direction in it—or else Change must be self-sprouting.

Most physicists admit only the last possibility. At least, most of them admit the reality of Change, but say that motions, even though they are repeatedly reversed by an unknown source of ‘‘absolute’’ energy, are now purely mechanical—are creations of chance or perhaps subscribe to the second law of thermodynamics. This inherited motion, originating in some unknowable past, even though it must be completely compensated periodically, is nevertheless a phenomenon involving pure mechanism. In some unexplained way, and with an unidentified source of power which is not a determining momentum,—for there is no determinism, they think, in their balanced mechanical cycles,—the oscillations of the fluid of matter make for new and haphazard combinations, and in reductions of energy-potentials, and thus for new but unpredictable life-sensations.

According to Professor Santayana, these changing appearances of the forms of things, without routine and subscribing to no laws, constitute the reality of spiritual existence. Both Santayana and Whitehead believe, nevertheless, that there is a spiritual character in man, which, though perhaps unable to alter mechanical routine, still possesses sufficient individuality to be able to receive, recognize, and enjoy the series of aimless and mechanically-founded appearances as and when they happen to arrive from the material world of oscillating brute existences.

There is little satisfaction in this picture of Spirit thus enthroned in impotent aloofness. Nor does its power to receive and enjoy ‘‘essences’’ particularly impress us. Spirit, according to such a definition, need never have been—and counts for nothing in being. This school has ideas which in one sense are even more materialistic than those of Bergson, for in denying momentum to the stream of life they leave no place for even a casual chain. And, more unreasonably still, no means remains by which knowledge might be acquired. This school virtually makes the fantastic assertion that ‘‘I know I cannot know.’’ Finally, it denies that there is any power (except Time) which could possibly overrule the doctrine of Conservation sufficiently to cause mechanical Change.

Of course the admission that mental power is a cause of motion—and especially of purposefully directed average motion, will never be made cheerfully by those who believe that mathematics supports and justifies their mechanistic views. If Time cannot be introduced as a causative power, then, so these materialists think, the identification of the cause of Change is hopeless. They are positive that in general the Conservation doctrine is sound; and they still have faith in many of the mathematical proofs supporting it. They earnestly hope, therefore, that the introduction of intangible and abstract Time as a cause of mechanical Change will retain Conservation—and somehow retain God also.

Here we are testing a different hypothesis. We believe that all sustained motions, when observed through even short periods, will be found to have been influenced by powers acting from an unmechanical source. This assumption is now being used in an attempt to explain gravitation, orbital cycles, the tides, and the rotation of the planets on their axes. We deny that Time, or any character now acting by virtue of a series of purely mechanical inheritances transmitted by means of Time, might now act as a mechanical cause that can explain the repeatedly reversed motions typical of all moving objects.

Having adopted this premise of caused motions that eventually end in cycles in which the motions are brought back almost exactly to their original status, and having used it to explain the planetary orbits, we now wish to determine whether it will explain also the difference in the number of axial rotations of the planets during each orbital revolution. Why does the moon rotate once only during each orbital revolution [1]—exactly once—while the earth rotates more than 365 times while she is encircling her central sun? Can these differences be explained by our theory?

The single rotation of the moon during each orbital revolution is what our theory should lead us to expect, for it is the conventional result in every whirlpool. Every object floating by itself in the whirlpool of a sink keeps one face constantly towards the drain, and therefore makes one axial rotation for each revolution. In one complete revolution the force of restraint succeeds in deflecting the direction of the current 360 degrees (no more nor less), and hence every particle of the current, and every object impelled by it as well, must, if not otherwise influenced, rotate once on its axis during one cycle of revolution. The vortical theory of orbits, therefore, should make us predict that the moon would keep one face constantly facing the earth—and that it would do so even if the period of the moon's revolution should change. With a different premise we have evidently escaped the difficulties described by Professor Moulton.

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[1] According to a modern theory the moon does not revolve about the earth but about the sun, the sun's gravitational influence being greater. This concept is explained in chapter X of *Discovery of the Earth,* by George Parsons.

The earth, however, with her many axial rotations during each journey about the sun, presents a different problem. Can we explain her rotations according to our theory? Obviously, different principles must be at work in the respective cases of earth and moon, hence, as our first step, we must enquire whether sufficiently distinctive situations obtain to account for the variations.

The first glance reveals a striking dissimilarity of condition—one, indeed, that might account for the different ratios of axial rotations to orbital revolutions. The earth as it revolves is influenced by a satellite which revolves with the earth as a focus, whereas the moon has no satellite. If the presence of a satellite can affect the axial rotations of a planet sufficiently to multiply that single rotation which the vortex theory leads us to anticipate, we shall have the desired explanation. A satellite like the moon should certainly have some effect upon the unbalanced energy-currents surrounding and impelling the earth. Let us see if we can determine its nature. Will the presence of a satellite alter the axial rotation of the central sun about which it revolves? This is the question.

When considering the artificially induced revolutions of the liquid planes in the glass desk weight, we observed that many of the various possible planes of revolution were so opposed to one another that all orbital motions excepting those in parallel planes were quickly cancelled. When, however, the centre of revolution is the central point of a sphere (and not a diametrical axis, as in the glass sphere), only one plane of revolution of all those intersecting this single point can persist without decided opposition. This query now suggests itself: Will *any one* of these various possible planes of revolution persist? And, if there should be one, what environmental condition will bring it about? Or, to put the question more specifically: Will the presence of an unusually dense object within a spherical energy-pool cause the plane containing it to rotate persistently, even though the rotation of every other plane is being cancelled by oppositions? We perceive that if the whirls persist only in those planes containing unusually dense objects there should be no plane exhibiting continuing revolution about the moon, but there should be one about the earth. In such case the moon should rotate on its axis once while revolving about the earth, whereas the earth, while revolving about the sun, should be influenced persistingly by the additional plane of revolution created by the presence of the moon.

It seems fairly obvious, too, that the multiple axial rotation of the earth is due to forces derived from unbalanced energy-movements focussed upon a point within the solar system. This point obviously travels with the earth about the sun, for otherwise the axial rotation of the earth would not be relatively uniform. Only unbalanced energy-movements acting in general along the earth's orbit can avoid a direct conflict with the energy-current which carries the earth about the sun. Yet, even if the swirling energy-current which creates the multiple axial rotation of the earth, travels about the sun (as a local whirl in a larger plane of revolution), there would, nevertheless, be some conflict between the two currents—for their movements are partly opposed. We should therefore expect to discover motions evidencing the effect of this opposition; and we are not surprised to find in the depressions of the fluid oceans visible proofs of the conflict of forces that the theory calls for.

The influence creating both the lunar tides and the earth's unusual axial rotation, must lie, moreover, in that plane, and in that plane only, which includes both earth and moon, for the unbalanced force persists only in that plane. The tidal depression visibly record this principle. Unquestionably, therefore, this local energy-current in that plane of the earth which cuts the moon, causes the earth's multiple axial rotation, the major part of its tides, and perhaps some of its other irregularities and wobblings.

According to this theory, a spherical energy-pool in which inertia is disappearing unusually within certain denser energy-volumes, should display the beginnings of many orbital revolutions about the exceptionally dense central sun, but, if the surrounding fluid should be uniformly dense throughout this particular exterior field, then all these beginnings of revolution will be quickly cancelled by equal tendencies toward revolutions in other planes. If, however, there should be within this field of evolution a second large and unusually dense structure, then that one spherical plane which includes the two unusually dense structures will display more than the usual energy of revolution. The forces tending to revolution in it will therefore override the weaker tendencies towards revolutions in the other planes, and will therefore persist.

This principle cannot be verified in the whirlpool action about the drain of a sink, for these planes of revolutions do not converge on a common centre, but revolve about a vertical axis. All parallel planes of revolution can persist in such case, for there is no direct conflict limiting survival to one fluid plane only. The important point is that all planes do persist whenever persistence does not involve unsurmountable conflict, and this fact clearly proves the principle that the revolutions in pools of evolution tend to continue. The energies of these planes of revolution tend therefore to repeat and accumulate. They increase until they attain certain maximum speeds—that is, unless conditions are such that the forces of revolution are quickly opposed, and completely cancelled in less than one cycle of revolution.

This principle being granted, it follows that if the plane of revolution contains a relatively dense satellite it should display an unusual amount of energy, and for this reason it should continue to revolve after the ordinary orbital movement has been annulled.

It is even possible to have orbital revolutions in opposite directions within one spherical cross-section, for the forces expressed in the different rings of this one plane do not directly conflict. We perceive, then, why the moon, having no satellite, is not surrounded by a continuing energy-whirl. We also understand why the earth with the moon as a satellite is a focus of persisting whirlpool energy-action which is sure to affect the central earth and cause it to rotate on its axis towards the east—that is, in the same general direction that the moon, urged by part of the same swirling energy-current, revolves about the earth. This theory seems to be fairly well supported by the facts of the solar system.

Thus Mercury has no satellites so far as we can tell and seems to offer only one face to the sun. This planet experiences librations, or wobblings back and forth, but these movements do not continue sufficiently to expose much more than one-half of Mercury to the sun's rays. The tremendous "absolute" forces involved in these librations are not identified by the astronomers. Venus, also, which appears to expose only one side to the sun's rays, has no visible satellites. Mars, on the other hand, with two moons both revolving towards the east, rotates in almost the same period as the earth. Jupiter, as we have already noted, rotates very rapidly, and has at least seven satellites revolving from west to east, and at least two others revolving in the opposite direction. The rotation of Jupiter, as we have said, is not uniform throughout the planet's mass. Near the equator Jupiter rotates at a surface speed of approximately 30,000 miles an hour, while another nearby point moves at a surface speed which is almost 350 miles an hour less than it should be at this latitude, if the mass were rigid. This difference in surface speeds can be explained only if some absolute force continually overcomes the sliding frictions between the contiguous sections. Saturn has at least nine satellites; and there are also a series of rings composed of a swarm of meteoric bodies revolving separately about the planet. Eight of the nine satellites revolve in one direction, and Saturn rotates rapidly on its axis, having a day of ten hours and fourteen minutes. Uranus and Neptune are so distant that nothing has yet been discovered about their periods of rotation, and no satellites have yet been discovered. Certainly, therefore, so far as the solar system is now known, the theory of axial rotations here advanced is supported by the facts.

This general explanation is sufficient for our purpose. If it is received with favour, then the mathematics of the situation may be developed to prove why the different planets with different sorts and numbers of satellites rotate as they do. This interpretation has followed from the corpuscular theory and fairly balanced pressure-pool. It may provide an acceptable explanation of certain facts which the classical scientists have yet been unable to explain acceptably. In the next chapter we shall use this theory to suggest explanations (very brief as they must be) of other phenomena which have puzzled the physicists who have attempted to explain events in terms of Conservation, and with the formulas of a generalized mathematics.

CHAPTER XXIX

THE CORPUSCULAR THEORY OF LIGHT

> So 'tis well
> That you should note these bodies how they rush
> In the sun's rays, because such rushes show
> What secret hidden forces lie below.
>
> Lucretius.

Modern science is in transition. Its theories and its formulas are tentative; or, at least, they are usually so regarded. And, to-day, particularly the hypothesis that a continuous ether fills the voids between atoms and worlds,—an ether that can undulate with perfect elasticity even though solidly continuous, and that can deliver energetic blows even though imponderable,—is hanging in the balance. A few years ago the belief that light-energy was delivered as the blow of such a medium was held fairly generally, and the philosophical difficulties of the concept were disregarded. Indeed it was (and still is to-day) considered impossible by many that the spaces between worlds should be filled to an appreciable degree with a ponderable substance; for such an assumption is contrary to the present explanation of planetary motions.

Yet, how can the fluid between worlds be continuous and imponderable, for how can a continuous fluid without open spaces undulate, and how can an imponderable fluid deliver energy by impact? If, however, the inter-world fluid does possess inertia of the usual kind, it certainly cannot be a continuum, for a fluid displaying inertia *continuously* through space must also display complete solidity, rigidity, impenetrability, and inelasticity. This is one aspect of the dilemma.

Reason seems to inform us that the fluid between worlds is ponderable, and that it cannot be continuous. It must be composed of separate inert parts—although it may be unusually diffuse and may display unusually swift movements of the parts. This concept, however, contradicts other beliefs. And yet, light delivers weight and mass (as well as energy) to the object which it strikes, and it appears incredible that light-energy might be delivered by the wave-blow of an imponderable ether. On the other hand, if the undulating fluid is composed of parts possessing inertia of the usual sort (a structure, for example, like that of a perfect gas) how can the planets pass for hundreds of years through it without appreciable retardation? This hypothesis, too, appears incredible at first glance. Perhaps, however, we can resolve the contradictions by offering a corpuscular theory of orbits. This has been done in preceding chapters. The corpuscular theory of orbits, however, suggests and involves a corpuscular theory of light.

But we need more than a corpuscular theory of orbits if we are to understand how light comes as an unusual energy-vibration in a ponderable medium. If the fluid between worlds is composed of oscillating bits of matter, what principle limits the range of their motions and reverses the motions into oscillations? Certainly that scientist who does not admit the presence and power of a mental Cause of general restraint is in difficulties here. He is unable to account for the reversed movements, for the parts of this fluid (more diffuse than the most perfect gas) show no tendency to attract and repel one another.

If, therefore, we find it necessary to surrender the ether theory, we must surrender also the belief that orbits large or small are created by forces of attraction acting upon inherited straight-line motions. When, however, we abandon the theories involving forces acting at a distance we find ourselves in the frame of mind of admitting that there is an independent Cause of restrained and limited motions. This fits in with the view of universal doings and becomings already outlined. The rejection of the ether concept supports our other convictions. We incline to accept the idea that there is a ponderable fluid medium with oscillating parts between worlds because it harmonizes with other hypotheses.

The scientists who have relied on classical theories for hundreds of years do not feel disposed to surrender so many of their beliefs at one time. The old ideas have proved eminently practical, whereas a new hypothesis may not be found so dependable. Many, therefore, prefer to confess frankly that they are making use of contradictory assumptions—all of which must be retained. This, they contend, is the most practical thing to do—at least pending the arrival of the time when either a modifying reconciliation can be affected or a satisfactory substitute hypothesis offered.

The theory of Relativity was first offered in an attempt to explain certain paradoxical light-phenomena in terms of what might still be regarded as pure mechanism; and, because in certain cases Relativity has seemed practical, some of the scientists have tentatively accepted it. Although the basis of Relativity, the source of the power that influences events, has never been described, the formula modified to fit the new concept has apparently fit certain experiences. After its preliminary success, the implications of Relativity were introduced into other fields in the hopes that the modifications of Newtonian mechanics which it called for would be found applicable to other puzzling phenomena.

The Relativists appear to be particularly hopeful that the principle of Conservation may be preserved—at least in its larger relations. Before the introduction of Relativity, certain phenomena seemed to indicate that energy had disappeared without compensation. The Relativity theory did away with these implications. When the Relativity factors were added to the Newtonian formulas, the new equations fit in with certain events exactly. If one could then but believe that the Relativity equations were really in correspondence with Conservation, the events which it so perfectly interpreted would thus be proved to be in correspondence with Conservation.

The Relativists also hoped to identify (in terms which might still be regarded as mechanical) the source of the power which causes general curvatures of the average matter-body in motion through inter-world space, and which thus affords a limited but finite universe of matter. The theory thus aspires to explain the nature of that power which we may call universal gravitational attraction—that which holds the universe fairly concentrated even in the presence of increasing motion. In the beginning, however, Relativity was introduced in an attempt to explain in mechanical terms those light-phenomena which otherwise could not be reconciled with Conservation. The reader must determine whether this explanation is satisfactory. Is it as complete, or as mentally reasonable, as that afforded by the corpuscular theory—an hypothesis introduced in this book as an explanation of gravitation of the tides, of atomic structures, of radiation, and which is here introduced anew as an explanation of the phenomenon of light?

Although there is no agreement as to the nature of the medium that undulates when light-energy passes, modern writers do agree that these energies pass through space in narrow-fronted waves. Christian Huyghens demonstrated (about 1680) that the phenomenon of light can be explained only on the assumption that light-waves have relatively limited transverse motions. This statement, supported later by other experiments, is still accepted. The polarizations, interferences, and diffractions of light seem to prove that light-energy is transmitted as a narrow-fronted wave motion. The important questions remain, however: Why are the transverse wave-motions limited? And what medium is waving? The theory of light, then, is the subject of this chapter, and we shall introduce it by first giving the views of others.

Before the twentieth century, no important objections to the ether-wave theory of light had been raised, but it was not known then that light delivered granular energy (and weight of the usual kind) to an object. Now, however, possessed of new knowledge, the tables are turned. Reason seems to assure us that the medium conveying the light-energy is composed of conventional matter. At least for some years there has been much questioning doubt. As William James remarked in his essay on *Humanism and*

Truth: "The ether, as Lord Salisbury said, is only a noun for the verb to undulate." The following statement of Mr. John Mills is fairly typical of the rather inconclusive view held in 1922:

> Matter which originally appeared to mankind as continuous and infinitely divisible has been shown to be atomic. Electricity, whose phenomena appeared those of an invisible fluid, has proved to be granular in structure. Why should we not expect that energy also should prove to be not infinitely divisible but transmissible only in finite amounts? There are three objections: First is the incompleteness of the evidence, second the subconscious effects of our scientific traditions and training, and third, a definite piece of evidence against the hypothesis which as yet has not been explained away.
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> A corpuscular theory for light was commonly accepted in Newton's time, despite a growing mass of evidence and theory in favour of a wave motion through an ethereal medium. Reflection was then explained as due to an attraction of the reflecting surface which bent towards itself the swiftly moving corpuscle, which the human eye later apperceived as light. As it happens, our present concept of reflection as re-radiation would also accord with a corpuscular theory for the transmission of energy through space.
>
> The evidence which finally dispossessed the corpuscular theory arose in connection with the phenomenon of interference.[1]

Bertrand Russell says that "as every one knows, light consists of waves", but "we do not know what it is that undulates. We only suppose that something must undulate because we find it difficult to imagine waves otherwise". Nor was Mr. Mills positive that the waves of light might not be regarded as the transverse oscillations in a material structure, for, in speaking of the corpuscular theory of light he remarked:

> The objection of the necessity of conforming to the known facts of interference is not, however, unsurmountable. It would seem to demand that the bounds of energy

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[1] John Mills: *Within the Atom*, p. 151.

> should have a length which might be large in terms of wave length that would be small as compared to the distance the energy travels in each second. In some way this bundle might also contain within itself something of the structure of a train of waves which would produce interference effects with bundles which might have been dispatched by another route.[1]

Mr. Mills, however, does not discuss the effect of this hypothesis on the theory that the planets move through an empty space.

Science is doubtless correct in assuming that light has a transverse energy-wave. Various experiences seem to justify this conclusion. Beginning, then, with this fact of limited wave-motions as a premise, let us expand our view. Two possible explanations of the nature of light offer themselves, and now that we feel compelled to surrender the concept of an ether, both must be considered. First, sunlight may be emitted from the sun as a series of projectiles, each with parts oscillating within a limited structure. These projectile-structures may successively pass through inter-world space as self-contained and cohesive wholes until finally they deliver a series of narrow-fronted blows to the earth. Or, secondly, light may consist of narrow-fronted energy-waves moving in a physically composed but relatively diffuse medium that fills the space between earth and sun. This medium may be composed of corpuscular parts which oscillate with enormous velocities. According to this theory, corpuscular masses radiating from the sun deliver their energies to the surrounding corpuscular medium, and the structure of this medium receives and transmits the energy very much as water receives and transmits through its waves part of the energy received from a falling stone.

The first of these hypotheses, the concept that light is a self-contained structure projected from sun to earth, is not plausible, for such a projectile would doubtless disintegrate when moving at this enormous speed through a space which is now known to be at least partly filled with the same bits of matter that constitute all material structures. Even though the parts of this fluid may be oscillating through a considerable range of movement, and moving at enormous velocities, the fluid may nevertheless be regarded as in general at rest when the movements and their influences are averaged through an appreciable amount of time or space. A static corpuscular fluid, however, would tend steadily to retard and decompose any structure passing through it—very much as stagnant air decomposes the molecular formation of the gust from a fan. Moreover, if light came to us as a projectile-structure through long distances, how could it spread out? How could its energy-delivery follow the inverse square law?

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[1] *Ibid.*, pp. 153–4.

Then, too, it has been discovered that the straight-line velocity of the translation of light-energy (at least of its motion relative to the inter-world space) as it comes from stars to the earth is invariant. Hence it appears impossible that a light-ray might be a projectile of the ordinary sort for a bullet shot from a stationary star towards the earth would move faster relative to an earth also stationary in respect of the inter-world space than it would move relative to an earth moving away from the star. Light-rays come with the same average speed to the earth from each of the double stars (binary stars, they are called, which revolve around one another like dumb-bells) although one star is moving towards the earth while the other is moving away, and this seems to prove (in terms of Newtonian mechanics at least) that light is not a body coming from the stars to the earth as a projectile. And there are other difficulties in the theory which need not be enumerated.

To be sure, the special Relativity theory of Professor Einstein affords a partial reconciliation of the constant velocity of light with the projectile hypothesis; but this theory seems otherwise unreal, and we cannot accept it. The Einstein hypothesis was first advanced as a possible explanation of the failure of light to show a drift with regard to the ether-medium after the Michaelson-Morley experiment had fairly proved that there was none. How, it was asked, if the ether (or any other fluid medium) were undulating, and thus transmitting light-energy, could ether-waves be delivered to an earth moving in respect of the ether and not be affected by this relative motion? After the Relativity theory had been proposed, it indicated that the velocity of beams of light towards the earth from each of two binary stars might well be equal even though the stars emitting the beams were then moving in opposite directions, and even though light was a projectile. Nor was this all: The developments of the theory indicated that the velocity of light from a star might be the same to all observers wherever located and however moving with regard to the star.

If there is no ether-drift, light cannot, according to Newtonian mechanics, be the wave of a stationary ether through which the earth is passing. Nor can light be the wave of any other kind of ponderable or imponderable fluid which is stationary with regard to the source of light, and therefore moving with regard to the source of light, and therefore moving with regard to the earth. And yet, if light comes to the earth as a projectile, the similar average velocities of light-rays from binary stars cannot be explained in terms of the old mechanics.

All of these objections will disappear, however, say the Relativists, if one will admit that Time is a certain type of variable. On this assumption, light might even be an ether-wave and yet display a constant velocity to all observers however they might be moving. And even if there were an ether-filler between matter-bodies there would still be no ether-drift. Do not the Relativists say that the variations in Time (as due to relative motion) so affect Space that the light-rays, as thus influenced by the space-time through which they pass, will show no ether-drift?

When Time is brought into the Newtonian formulas as a changeable quantity, the possibilities of the old mechanics (with its formulas of energy rigidly limited to the possibilities that could be developed from equations with unalterable time-factors) are tremendously extended. Almost every mechanical situation must be re-interpreted. If Time is a variable, or can be treated as if it were a variable in certain mechanical situations (perhaps the more reasonable way of putting it), all mechanics is somewhat affected by the new view point. And when Time is introduced into Newtonian formulas as just the right sort of variable (the sort that one might artificially select for the very purpose of making the old formulas exactly fit both the new concept and a certain experience), when the supposed changes of Time are chosen deliberately so that they exactly cancel these changes in relative motion which should appear according to Newtonian mechanics, but which, in fact do not seem to appear in certain light-phenomena,—that is to say, when Time is factored by a divisor involving relative velocity so that duration will approach zero-value in the exact proportion that relative velocity approaches the uniform figure set by experiments as being the straight-line velocity of light-energy (the Lorentzian transformation formula),—then light might even be an emission like a projectile, the spaces between worlds might be voids, and yet the light-rays from binary stars would reach the earth with invariant speed, and would even pass differently moving observers between stars and earth at the same relative velocity. This theory, moreover, might even be made to produce a new explanation of gravitational energy.

According to the classical theory the constant velocity of light between worlds was expected, for the ether was supposed to undulate to carry the light-energy at the constant average speed natural for undulations in an ether-medium. Every earth-structure, as is known, has its natural rate of undulating vibrations, hence it was not regarded as extraordinary that the elastic and imponderable ether-continuum (supposed to be filling all voids) should transmit energy with uniform velocity by its wave-motions.

But the Michaelson-Morley experiment revealed an unexpected absence of an ether-drift, and then Einstein introduced a new concept. According to him, if an observer were in a rocket speeding from the earth towards the sun at ten thousand miles a second, the sunlight, whether projectile or ether-wave, would pass the moving observer at the same relative speed that it reached the earth. Relativity assumes that the relative motion of the rocket towards the source of light so reduces the *time* of the observer on the rocket that when this smaller time-quantity replaces the larger in the

Newtonian formulas involving relative velocity (velocity itself normally [in respect of our frame of reference] being a function of time), it will be discovered that the velocity of the passing light-ray is the same to all observers wherever they happen to be, or however they happen to be moving with regard to the source of light. This conclusion flows from the changed formulas; but this is not remarkable, for, as stated, the formulas were altered to give this precise result. It *is* remarkable, however, that the idea of variable Time should be credited as a source of mechanical change.

The new formulas, of course, are fairly practical as provisional working rules for interpreting some events not yet explained otherwise. They have temporary value; but, surely, the concept of variable Time as an influence in mechanics is not sufficiently reasonable nor sufficiently proved to warrant the acceptance of its implications throughout the domains of science and philosophy. Surely the basis of Relativity—the very concept that Time as it enters mechanics might be subject to change, or might take any part in the transmission of energy—will soon be discarded. No doubt the constant average velocity of light—so far as it is constant—will be explained in other terms—perhaps even in harmony with the corpuscular hypothesis, and certainly in terms of understandable definitions of matter and energy.

Professor Chamberlain seems justified, therefore, in asking this question: "Are those postulates [of Relativity] really in any sense demonstrations or are they merely weird speculations devised to escape the dilemma of a disappointing experiment?"[1] And again: "If a persistent student tries to follow the line of the new thought back to its source, is he likely to land elsewhere than in the infinitesimal, or the inaccessible, or the indeterminable?"

Professor Charles Lane Poor, of Columbia University, denies the applicability of the Relativity energy-formula even to those phenomena where it seems to represent the facts correctly. Thus he writes in the concluding pages of his book that "The astronomical evidence, cited by Einstein as complete and satisfactory proof of the Relativity theory, fails to support his hypothesis. His hypotheses and formulas are neither *necessary* nor *sufficient* to explain the observed phenomena.''[1]

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[1] Crowder Chamberlain: *A Preliminary Essay to Gravitation versus Relativity* the book itself by Charles Lane Poor.

On the other hand, Dr. Erwin Freundlich, whose book on Relativity received the endorsement of Professor Einstein, says that ''it was imagined that the source of light only excites the periodically changing states of the luminiferous ether, which is at rest, that is, which does not share in the motion of the matter (source of light), and that these states then propagate themselves with a *velocity that is characteristic of the ether,* and with a velocity that makes these states perceptible to us as light waves. This view [at one time] had apparently won the day.''[2] Dr. Freundlich says, however, that later the quantum hypothesis made this concept impossible. According to him, the ether-wave theory is not needed now as a means of accounting for the constant velocity of light, for the special theory of relativity robbed ''the assertion: 'the ether at rest' of its significance, since we may arbitrarily define any system as being at rest in the ether, as far as uniform transmission translations are concerned. . . . The quantum hypothesis, in raising light-quanta to the rank of self-supporting individuals, deprived the *velocity of light* of its character as a constant that is characteristic of the ether. Thus, our view of light-quanta again leads to a kind of emission theory of light.''[3]

That is to say, according to Relativity the relative velocity of light will be uniform whether the light-ray is an ether-wave or an emission of particles. It is no longer necessary to assume that light is an ether-wave in order to account for its constant relative velocity, and this conclusion is particularly satisfactory to the physicists because the quantum-hypothesis indicates strongly that a light-beam, at least at its beginning, represents an abnormal movement of matter.

Nevertheless, Sir Oliver Lodge still claims that there is an ether. In an article about him in the *New York Times* of October 7, 1928, this question is asked by Mr. Augustus Muir: "Is there a living scientist of the front rank to-day who will deny the existence of the ether?" In his book, *Ether and Relativity,* Lodge asserts that ether is the ultimate essence that we are made of. He says that "Ether is our primary and permanent instrument" and that it is "in connection with this ether that we are able to express our thoughts and feelings." He describes ether much as Haeckel described it—that is, as almost the same thing as an imponderable spiritual power.

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[1] Charles Lane Poor, *Gravitation versus Relativity,* p. 254.
[2] Erwin Freundlich: *The Foundation of Einstein's Theory of Gravitation,* p. 69.
[3] *Ibid.,* pp. 69-70.

Now if the ether between matter-bodies is to be described as a continuum entirely lacking material (and also spiritual) qualities, we should feel obliged to abandon the idea that a light-ray travels as an ether-wave, for we cannot account for the deliveries of conventional energy by a medium without inertia. And yet it seems impossible that the space between worlds should fail to be filled with matter and energy of the usual kind. We repeat our former argument: How can empty space remain quiescent alongside of an active energy-field notable for the motions of its inert parts? How can this space refuse to accept any of these material parts, and be occupied solely with intangible "attractions"—forces supposed to be active only in certain directions? Or how can this space be filled only with immaterial lines of force, or energy-strains, either balanced or unbalanced within certain distances?

We do not believe that there is an imponderable filler of space capable of expressing, or of participating in, mechanical reality. Space has no reality in physics except by virtue of its material spacings and relationships. We have concluded that the regions between worlds are filled with a stream of flowing (and oscillating) corpuscles sufficiently powerful and dense to drive the planets. Between these corpuscles there is an unimportant (mechanically speaking) void. We believe that such a corpuscular fluid, if possessed of the qualities reasonably attributable to it, might transmit light-waves with uniform velocity even from binary stars to the earth. We have also reached the definite conclusion that Time is not involved in the delivery of motion when one smallest bit of matter collides with another, and we therefore think it impossible that changes in Time (even if they could be conceived of) should have any effect on any energy-deliveries.

Now, obviously, the corpuscular medium between worlds must be extraordinarily diffuse. Hence its parts must oscillate very rapidly. For this reason it must be extremely elastic. It should, therefore, be able to transmit energy-waves with great velocity yet with comparatively little transverse breadth of each wave. Yet the haphazard energy-waves should be transmitted (in the average) from one to another of the oscillating parts of a self-contained structure with the average component-velocity of these oscillations in these directions. If, therefore, light is transmitted as an energy-wave in a corpuscular medium, and yet comes in approximately straight-lines from the stars at a speed of about 186,000 miles a second, the fluid-medium in these spaces must be composed of corpuscles which, in the average, oscillate so as to transmit motions *in one average direction* by contact at this enormous speed.[1] And the similar times of arrival at the earth of light from binary stars is accounted for according to the corpuscular theory in the very manner suggested by those who believe that there is an ether-continuum occupying the spaces between worlds. The velocity of light is merely the average velocity of the transmission of the energy through contacts by the average bit of matter in that corpuscular medium which does transmit the unusual energy-series known as light.

The suggestion that the inter-world regions are filled with oscillating corpuscles rather than with imponderable ether is in keeping, as I have said, with the corpuscular theory of gravity. It harmonizes also with the concept of a general energy-equilibrium, and with the explanation of the tides as already given. It does not permit one to suppose, however, that light-energy from a star will reach observers wherever they may be, or however they may be moving, with constant velocity. Nor has it yet accounted for the failure of Michaelson-Morley to find a drift in light-rays due to the earth's motion relative to the inter-world medium transmitting the light. It does account for the uniform velocity-arrival of light from each of two binary stars, but explanations of other phenomena are still required. As William James said: "To give the theory plenty of 'rope' and see if it hangs itself eventually is better tactics than to choke it off at the outset by abstract accusations of self-contradiction."

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[1] It should be noted that the velocity with which the energy of light is translated through space is not the same as the oscillating speed of the particles composing the fluid which transmits the energy by contacts of parts. Thus sound passes through air at about 370 yards a second although the air-molecules that transmit the energy move themselves in all directions at a velocity of about 500 yards a second. According to this view, the velocity of the movement of light-energy from star to earth, is by no means the maximum velocity of matter in the universe.

The corpuscular theory of light-transmission is supported by the knowledge that light passes with different velocities through various transparent media such as air, water, and glass—all of them structures only partly composed of that fluid which fills the space between the stars. This change in the velocity of light with a change of density indicates strongly that the light-energies are transmitted from one to another of the parts. It has also been discovered that when a transparent structure is moving relative to the earth (is moving, that is, relative to that large field of energy-equilibrium which maintains the average motion of the earth) the light-rays passing through the structure will partake of its relative velocity.

As was proved by Fizeau (in 1859), a light-beam moves faster through a tube of water in the direction that the water is flowing. Sir Oliver Lodge finds that the results of Fizeau's experiment are "in strict accord with classical ideas of a stationary ether and with the ordinary laws of optical phenomena."[1] It is true that he does not give us the location of that point with regard to which the ether is "stationary", but we can agree with him, if the corpuscular fluid enveloping a certain star were flowing past this star towards the earth, that we should expect the light-energy from this star to come to the earth with greater relative velocity than from a star moving in the opposite direction. According to our theory of environmental conditions, as already set forth in chapters on gravitation, the enveloping energy-current cannot brush past a star steadily in one direction, for the motions of the stars are created by the impulses of this current. All energy-currents closely enveloping a star must, in the average, be stationary as regards it, hence no drift of the light-waves need be expected in earth-experiments from light moving in relation to this medium that is relatively stationary as regards the earth. Here the corpuscular theory helps us to understand the light-phenomena.

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[1] Charles Lane Poor: *Gravitation Versus Relativity*, p. 55.

If light is transmitted as a series of unusual energy-waves carried on by means of the moving parts of a very diffuse but substantial medium, we should expect that certain colours of light would correspond with nerve-activities as typically responsive to certain frequencies of energy-impulses, for the colour of light is merely an ''appearance''—or a mental appreciation of mechanical data. A certain energy-condition in the external world is made known to our conscious minds by the colour sensation. The colour is not the effect itself of a series of unusual blows, but it is the distinguishable mental sensation which the series of blows makes known to our minds through the medium of the vibrations of a certain part of our body. A typical part of the eye vibrates in response to each typical series of visible light-impulses, and when this vibration is recorded in the brain the mind knows that a certain ''colour'' of light is then being delivered against the external retina. The receipt of impulses of a certain frequency builds up oscillations in a certain part of the eye—that part which is so constituted that it has the same natural frequency-rate of vibration. We shall return to this concept; but certainly this explanation, brief as it is, makes it reasonable that a colour (''red'' for example) is due, not to the average velocity of the light-impulses, not to the total energy of a series of impulses, but solely to the fact that ''red string'' of the eye builds up a recordable vibration whenever light with the frequency of impulse of the colour known as ''red'' happens to strike this particular part of the retina. Of course the energy-delivery must be one (neither too faint nor too intense) that will permit this string to vibrate with appreciable intensity.

If this theory is sound; if a certain colour-sensation is truly the mental appreciation that arises when a certain string of the eye is vibrating harmoniously with a certain frequency of light-impulses; if colour changes with frequency; if, that is, the ''red'' string ceases, and a different string begins to vibrate harmoniously when the series of impulses exceeds the frequency which harmonizes with the natural rate of vibration of the ''red'' string; if these hypotheses are true, then, we claim, both the frequency and the colour of light should vary with the motion of the inter-world fluid medium relative to the object on which the light impinges. If a star is stationary with regard to the inter-world medium, the series of light-impulses from it should be received on the earth with greater frequency when the earth at the time is moving through the medium towards the star than when she is moving away from the star. This relative motion, however, would not influence the velocity of light in reference to the medium itself, for, as already stated, the velocity of translation through, and in regard to, the inter-world fluid is controlled by the velocity of the oscillations of the corpuscular parts.

The conventional scientist, however, who denies that there is a corpuscular fluid between worlds, is unable to account for the limited wave-fronts of the light-rays as called for by his ether-wave or electromagnetic theory. Nor can an explanation be given in terms of Conservation of the quick reversals of the wave-motions (or of their energies). This is true whether the undulating fluid be regarded as an elastic ether, or as an electromagnetic fluid—or even as a medium composed of corpuscles. If, however, one will deny that there are attractions and repulsions at a distance, and deny that Conservation is a reliable principle, and accept the theory that there is a purposefully created energy-pool of oscillating parts in the realms between worlds (with energy-movements quite like those in a pool of water), and if he will then admit that this substantial fluid has its own restrained structure and exterior source of motion, and an energy-measure sufficient to create the repeating planetary orbits and the tides, he can readily conceive how the parts of such a structure might have limited motions (like thermal motions), and how it, with these limited oscillations, might transmit light-energy over limited wave-fronts. Such oscillations would be limited in breadth in the same fashion that the waves of the ocean are limited in height—and that all motions of all sorts in the universe are limited.

The Conservationist who admits of no Power of general restraint other than his unexplained attractions which do not apply to the fine relations such as obtain in a perfect gas, who recognizes no Cause that might limit the movements within structural formations whether of atomic or sidereal proportions, who conceives that the spaces between worlds are void of everything except electromagnetic strains, and forces of "attraction" acting toward the denser bodies, is confronting an insoluble puzzle. He cannot better account for the constantly reversed motions of energy of the earth than he can explain in intelligible terms the thermal activities of gas-molecules, or the restrained oscillations of the electrons within the atom, or the failure of his law of attraction to operate at the surface of an atom and within a perfect gas.

When, moreover, we consider the polarizations and interferences of light, we find that they may be explained in terms of the corpuscular theory. If light-energy is being transmitted by oscillating waves of moving corpuscles within a fluid-structure relatively static as a whole,— just as the energy of the falling stone is transmitted by the limited oscillations of the molecules of the water,—then, when two light-rays meet, they will express an energy-opposition, and the range of oscillatory movements of the parts of the two corpuscular formations that are transmitting the energy may be reduced (temporarily, at least) to such an extent that the mashed wave-structures can no longer deliver the series of rhythmic impulses to the retina, which, when transferred to the brain, are recognized as the sensation of light. Polarized light seems to be that flattened or disc-like arrangement of the normally rounded oscillating light-structure, which, when moving at a certain angle to the eye, penetrates its webbing without delivering the particular series of rhythmic impulses to the substance of the eye as necessary for mental recognition as a typical phenomenon worthy of mental consideration. In interferences, however, the wave-structure may reach the eye from any direction without giving the light-effect. The colliding wave-structures of interfering light-rays seem to be mashed into such narrow-fronted and spear-like formations that at certain angles of reflection the waves do not deliver appreciable vibrations to the physical netting of the eye.

The phenomena of polarization and interference do not prove that light is transmitted as the wave in an ether-continuum. On the contrary, the results appear to show that the restrained and limited structure of a light-wave is composed of granular parts which may, by collision, be brought, temporarily at least, into new and unusually compressed relations with one another—a result that could not possibly be derived from a continuum. Indeed, knowledge of the granular formation of the matter of our eye should lead us to anticipate interference-phenomena. We should have supposed (unless the oscillatory wave-structure of light passed through the eye with some minimum width of front) that the sensation of light would not be recorded. Interferences and polarizations do not prove, therefore, that the ether-wave theory is sound. This concept is essential only for him who is a Conservationist, and who insists that "attractions at a distance" account for orbits, and for other reversed cyclical movements, and who therefore refuses to concede that there is a substantial fluid in the interworld spaces.

According to the corpuscular theory, the frequencies of light-impulses are not affected by interferences and polarizations, but the transverse waves (in one or in several planes) are temporarily reduced in width by them. If, therefore, it could be proved that the forward energy of the light, made invisible by an interference, persisted afterwards, we might be assured that the collisions of rays from which the phenomenon of interference springs, do not destroy the series of energy-impulses, but merely alter (and only for the time being) the normal range of motions of the particles constituting the energy-waves. If a light-wave energy-structure, after being compressed by an interference, were permitted to move far enough thereafter, its parts would more than likely be returned to their normal range of motion in all directions, and the light-waves would probably once more be capable of giving the sensation of light. If light were polarized on this earth and reflected to an observer on the moon, it would probably reach him there with normal structure and with conventional visibility. Certainly there is no evidence now of polarized light reaching us from the moon. If the principle could be demonstrated that polarized light soon became normal, it would prove fairly definitely that a light-ray is merely a series of waves in a material medium moving with a certain energy and frequency, the parts of the wave-structures being held within definite limits of oscillation by the balancing pressure acting from all sides.

Near the end of the eighteenth century, a young Frenchman named Fresnal demonstrated that light would diffract around the corner of a narrow slit. He supplied the data needed, it was thought, to support Thomas Young in his assertion that the theory of Christian Huygens was correct, and that light was an undulatory ether-wave—a wave like that in a taut rope held at both ends, but undulating transversely. Yet it was not understood what principle permitted a continuous ether to wave transversely and progressively; and no explanation, as we have said, was given of the origin, limitations, or reversals of the sidewise energy-movements. How can there be repeatingly reversed motions, or limited transverse energy-waves in any medium except that some force act upon the medium from the outside to reverse its waves? Must not all elasticity be thus explained? And how can there be waves in a true continuum such as ether was supposed to be?

In 1873, Clerk-Maxwell developed a mathematical proof that light was an electromagnetic wave. This, however, does not help much, for, as we view it, so incorrect is mathematics when applied to physics that when a relationship of physics appears to be exactly demonstrated by mathematics it is thereby proved inexact. Moreover, not the Cause but merely the routine of an event of a certain kind is formulable mathematically. Nor is our understanding of the fundamental nature of light improved by saying that it is an electromagnetic wave, for we have not yet been told what electricity and magnetism are. The definition of light as an electromagnetic wave seems to refer to behaviour only. The constitution and activities of the electromagnetic field have never been described in conceivable materialistic terms. It still leaves us with a matter-void between worlds. Yet the modern scientists appear to be inclined to favor the theory of Maxwell.

Mr. M. Luckiesh writes, for instance, that "The Maxwell electromagnetic theory overcame many obstacles with everlasting glory. The ether was still retained, but its properties were now somewhat different from the mechanical properties of solids as the wave-theory assumed previously."[1]

It seems to us that the mystery deepens. Mr. Luckiesh tells us that: "Light and radiant energy are even considered to be interchangeable. It has been definitely proved that a beam of light passing close to a large mass such as the sun is perceptibly bent towards the mass due to gravitational attraction."[2] This indicates to some minds, to be sure, that light-energy is conveyed through a mass-movement, but no modern theory teaches that magnetic attraction is delivered by the unbalanced momenta of masses moving in the magnetic field. Yet how can it be possible on any other terms that light might be an electromagnetic wave and also have mass? Or how otherwise can an electromagnetic field display unbalanced energy? We cannot imagine, as does Einstein, that inertial mass is converted into pure energy (which though no longer associated with matter has properties recognizable in mechanics) as the relative motion of the mass approaches the speed of light. If light delivers energy of the usual kind by its collisions we must conclude that the energy-movement involves mass and inertia of the usual kind.

Other phenomena indicate that a light-energy is translated as the wave in a conventional material structure. The sun emits radioactive masses, and we have no reason to suppose that when these objects come to the volume surrounding the sun they then immediately stop being masses, and that, from this time onward, their mass-quality is represented by nothing more substantial than mysteriously created transverse energy-waves in an immaterial ether—or in an equally immaterial electromagnetic field. How could this be so? What becomes of these radioactive masses which began the energy-movement with convential inertia? If they do not vanish into nothingness, where are they? And what restraining energy can stop them at the very edge of the sun if the space around the sun is ether-filled? But, if stopped by an electromagnetic ''field'', whence does this ''field'' derive its unbalanced energy of resistance? Does the electromagnetic ''field'' repulse matter at a distance? And does it repulse masses from only certain directions?

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[1] M. Luckiesh: *Foundations of the Universe,* pp. 49–50.
[2] *Ibid.,* pp. 54–5.

Surely the imagined field between worlds, whether etherial or electromagnetic, has no such powers of restraint! Do not the scientists tell us that it has no ability to retard the earth in its course about the sun? If, therefore, these radiating masses are not stopped by the inter-world field, if the attraction of the sun is insufficient to stop them, then unless the space were filled with something substantial, some radiations would come to the earth from the sun as projectiles. There is no evidence, however, of such mass-motions continuing indefinitely and unretarded through space. And for still other reasons we have concluded that the space between worlds is filled with a fluid-structure composed of tiny, oscillating, and therefore energetic, bits of inert matter, which, because they are equally as ponderable as the radiating masses, receive and transmit the unbalanced energy of these radiations, delivering it to all the surrounding regions by means of limited transverse energy-waves. Certainly, unless we do believe this, there seems to be no accounting for the delivery of energy and mass by the light-and-heat-waves and no explanation, either, of the storage-place of those masses which radiate into the inter-world regions. Even the molecules that once comprised the atmosphere of the moon are supposed to have radiated (molecular motions here overcoming gravity) into the spaces between worlds, and yet this space is now supposed by some to be a material void. Not altogether a void, however, for it is supposed to be filled with imponderable energies of attractions and pure electromagnetic strains. This concept, of course, is necessary if one is to account for orbits according to the theory of ''attractions''; but this theory of ''attractions'' is unsatisfactory for it does not explain the contradictions which it introduces.

Here, then, is a puzzling situation if light-rays are really imponderable electromagnetic vibrations, but easily understood if light-energy is transmitted by waves in an oscillating fluid of corpuscles. Assuming, then, that the corpuscular fluid theory has elements of reasonableness, let us consider it further that we may see how well it fits in with other facts.

The white light of the sun is a composite. According to the conventional theory the colors of light correspond to different frequencies, or wave-lengths, in the light-rays. The designation ''wave-length'' is in one sense a misnomer, however, for the transverse breadth of the wave is not referred to, nor any wave necessarily connected up *structurally* along the line of translation, but merely the distance travelled by one radiating impulse from the source before the next one leaves it. This distance between waves (at least for waves of the same frequencies) varies of course with the velocity of the radiation. The wave-length, then, is merely the particular spacing along the line of translation of the centres of the waves. It has no necessary reference to the width or length of a single wave, and it is a generalization in space and time. It has no unit reality. The different waves, moreover, may not be connected. A single wave, nevertheless, like the wave spreading in a pond from a single disturbance, must have its own definite wave-length as a physically grouped phenomenon, and its own average width of wave-front. Two radiations, however, are required for the measurement of the conventionally-described ''wave-length''. When a radio wave (moving at approximately the speed of light) is said to have a ''length'' of 500 meters, it is meant that one radiating impulse will have travelled 500 meters before the next impulse of this particular series is emitted. When thus understood, we can say in general terms of radiations with uniform velocities that their wave-lengths vary inversely with their frequencies.

At first glance it seems reasonable that the characteristics of the single wave should control the light-sensation as derived from a particular beam of light. This, however, is not true. Of course the unit of energy of a light-impulse is the energy delivered in unbalanced fashion by the single wave, and the total energy-delivery to unit area during a second equals the energy of the single wave multiplied by the number of separate wave-impulses against this area during the second. Total light-energy as delivered upon unit cross-section, depends upon wave-frequency, therefore, but it depends also upon the velocity and inertia of the striking mass. The average intensity of light, therefore, but not its color, is proportional to the total energy-delivery to a certain area during each second. The particular sense-datum known as the colour of light, as already pointed out, when regarded (as it should properly be) as a physical sensation interpreted by the mind, is present or absent to the brain according to the presence or absence of intensive vibrations in that one particular part of the retina which must be cumulatively affected by the particular series of light-impulses to be known to the mind as this colour. Colour, therefore, like the pitch of sound, varies with frequency; but this is so only because different frequencies build up intensive vibrations in different physical parts of our bodies, and because each part records its own characteristic energy-movement whether of colour or sound.

A single wave-impulse of sound has no musical pitch; it is merely a click. It affects with equal force every harp-string of the ear. Only one of all the strings of the ear will build up a wide oscillation harmonious with a certain *frequency-series of impulses.* No doubt, therefore, the receipt of a single light-impulse will not give the sensation of colour, for only one string of the eye identifies (through the correspondence of its own natural period of vibration) the particular physical condition of energy-frequency obtaining outside, and only such a mental interpretation, is called a colour. The brain records the receipt of a colour-sensation only when the vibrations (as transmitted to the brain by the nerves) of a certain part of the eye-mechanism are delivered in a regular and sufficiently intense rhythm. The unconscious mind, realizing at this time that only this certain part is oscillating, understands that only one type of energy-frequency is then affecting the external eye. The inside mind is thus able to identify the external energy-presence.

A colour-sensation, therefore, is, *per se,* nothing more than the interior mental symbol standing for a certain generalized exterior mechanical phenomenon extended in time and space. It represents the mental appreciation (an appreciation in mental rather than physical terms) that a certain external mechanical situation obtains. The mind realizes that this situation generalized in time and space must obtain or else this particular nerve would not be vibrating as it does. The colour ''red'' is the mind's distinguishing tag indicating that external energy-conditions are thus and so. It is an ''appearance'', truly—a mental symbol. And it has nothing to do with unit reality, hence we can obtain no knowledge of the single basis of mechanical reality from it.

Differing from the English philosopher, Dr. F. H. Bradley, from John Stuart Mill, and from many others, then, we contend that an ''appearance'', or sense-datum, represents more than a mental phenomenon. The ''appearance'' can be what it is only if other mechanical facts are. The color ''red'' means more than the mental sensation of ''redness''. Likewise the numerals of the speedometer represent more than a sequence of numbers. An ''appearance'' virtually proves that a particular short-cut method has been devised by the mind for obtaining information about an external, generalized, and orderly mechanical situation quickly and readily. And, since the particular signal-system has been mentally arranged, it is not remarkable that the mentally received signal gives the mind information about the mechanical situation. No more is it remarkable that the appearance of the numbers in the speedometer advises the driver of the speed of the car. The ''appearance'', therefore, is a convenient signal which the subconscious mind of a man has arranged within his body as an easy means of knowing (without recourse each time to laborious reasoning from the involved statistics of experience) the nature of certain generalized types of external mechanical situation.

The mechanical impulses beginning the chain of events that conclude in an "appearance" are usually transmitted to the brain through a mechanism arranged to deliver one symbolic signal (one "appearance") as proof of the presence of certain complex external condition. Again we should note that it does not interpret unit reality for us. This understanding, however, is not enough: The fact that the last link of such a mechanical chain connects an energy-impulse with a mind, should be proof to reason that part of the mechanical movement is transformed into a mental flow. It is this flow, in turn, which really gives rise to the mental appreciation, or to that which we call an "appearance". The reality of "appearances" signifies that there is an Evolution of matter into mind. This realization, however, indicates the nature and order of Change.

Thus, conscious Reason is able to interpret, not only the "appearances" themselves, and the general nature of the situation, but also the process of Change from which such "appearances" develop. It may also disclose the rationally necessary unit reality.

Now, while the extended development of these theories is more appropriate for another book, it seems necessary that we should have a general understanding of the mixed nature of "appearances" if we are to develop a reasonable theory of colours. I shall therefore carry this discussion a little further.

The color "red" is indicated to the mind whenever the nerves connected with the "red string" of the eye (if we may call it this) are tingling regularly and strongly. So long as this string continues to vibrate with a certain intensity and rhythm the colour-sensation remains. And the vibration continues even for a short time after the external impulses creating it have ceased. This principle explains the persistence of vision which unifies the discontinuous moving pictures to the mind as a continuous flow of images on the screen.

If, however, there were no "red string" in the eye, the colour "red" would never be known as a separate sensation. Or, if the strings of the eye, or the nerves leading to the brain, should be crossed or blended, a person would be unable to distinguish between the two colours. The colour "red" of the human eye may therefore appear as "blue" to an animal whose eye is differently constituted. Or the animal may "see" light-frequencies invisible to men.

Whatever the signal-system may be, the sense-quality of a certain signal is not particularly important. It is of no great moment whether a certain series of energy-impulses reach the brain as "red" or "blue"; but, if we are to obtain exact knowledge of the exterior conditions, it *is* essential that a certain colour should always be sensed whenever a certain external condition obtains. This signal, when tagged as a sensation or "appearance" for the convenience of the mind, and when the body is properly arranged, gives reliable knowledge of the presence of this generalized type of exterior mechanical order with which the mind itself is not in direct touch. The sensations, as in the case of colour, may reach the mind by means of a series of energy-impulses transmitted through the body, but these impulses, as received at the brain, are, to a large degree, mechanically typical of the external impulses.

Knowledge, however, may be obtained otherwise: The mind may act upon a body which itself is being changed by the energy-receipts. The mind, therefore, not only receives knowledge of the energies of its environment through the transmutation of matter into mind, but also acquires knowledge from the effects of the application of its mental energies,—subjectively, that is,—upon material objects.

If a man shoves me with a stick, I realize the nature of the power that is used, although not the man, but merely a stick, pushes me. The push of the stick is mechanically representative (in general terms at least) of the shove the man could give if his hand were in direct contact with me. Colour-sensations are similar. The repeated impulses received at the brain act as representatives typical in rhythm, beat, and power of the exterior, orderly, and generalized energy-situation, and, therefore, adequately represent the situation. But in the different case to which we have referred, where the energy-impulses affect the object (it may be the man's body) which a mind is operating, the mind can still obtain knowledge of the mechanical situation. In operating its own body (or an object outside of its body), the mind can perceive the effects made in the body-structure by the delivery of certain kinds of energy-impulses. In this indirect way the mind may become aware of the frequencies and quantities of the energy-impulses which make the changes. Thus, similarly, a man pushing a wheelbarrow becomes aware of the slopes in the ground over which it rolls.

Yet there are cases in which there are no such typical mechanical representations to the brain, either objectively or subjectively. The brain does not feel the mechanical effect of the motion of an automobile upon the speedometer; nor does any typical mechanical representation of this movement reach the brain or any other part of the man's body. Nor does the mind itself here operate anything. The man does not here become aware of a mechanical effect, either directly or indirectly, but he sees merely that a certain number has appeared in a certain machine. Even this, however, is significant, for, as we have said, the mind of the man has organized both the mechanism of the speedometer and its number-system. The mechanism has been mentally arranged to receive and to number mechanical impulses in a way that can be mentally accepted as typical of the particular speed of the car. For these reasons the mind is able to learn from the appearance of a number that an automobile is moving at a certain speed over the ground.

Now the knowledge obtained by the mind of the energy-condition of the exterior world through sensations, whether directly, or indirectly, by means of mental tags,—whether impressed as a mechanical contact as in the case of a colour-appearance, or derived in some such way as from an exterior number-system in a speedometer,—is far from being intangible and inexact. Plato, in his famous illustration of the cave, likens the ideas that ordinary men acquire of the realities of the exterior world from sense-impressions (and not from

Platonic "ideas", or appreciations of universals) to the concepts that a cave-dweller might attain, who, sitting with his back to the light, sees nothing but the fleeting, misty, and thin shadows thrown on the wall of the cave by external objects moving back and forth before the entrance. Many writers still contend that the ideas drawn by men from mental appearances reveal and indicate no more of the true reality than these shadow-shapes of the cave-dweller. Thus, Dr. Bradley says: "The truth belongs to existence, but it does not as such exist."[1] Or, again: "and of the Thing-in-itself we know that if it existed we could not know of it; and, again, so far as we know of it, we know that it does not exist."

I believe that these views are erroneous. We cannot prove the assertion that the ideas of men are nothing more than shadows disassociated from the material realities themselves. On the contrary, when the quality of an "appearance" is traced to its origin it will be found that it has a deep significance of a certain generalized mechanical kind at least, that its contents carry an essential meaning which should be revealed to a mind-power similar to that which arranged the signal-system. Thus the colour "red" represents the inner nature of a certain type of orderly, mechanical (but mentally arranged) situation which alone is capable of producing this particular mental sensation. And the products of other contacts of mind with matter, such mental sensations, for example, as those derived from the energy-impulses of sound, smell, heat, taste, and touch, are possible merely because there is this planned signal system, and this direct and significant association of mind with matter. All sensations, therefore, have some valid mechanical reference, and have, therefore, direct mechanical significance. All are products of systems mentally arranged for the interpretation of the different orderly associations of various quantities of matter in motion with mind. All are capable of giving real knowledge of the mechanical environment.

Returning, however, to the discussion of light, the shades of colour appear to vary in a direct proportion to wave-frequency. Colours, apparently, are not affected by changes in relative velocities unless these changes also alter the frequency. The intensity of light, however, one should think, must vary with changes in the relative velocity of light. Can we assert, however, that starlight moves with more than one relative velocity to the earth? Perhaps not.

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[1] F. H. Bradley: *Appearance and Reality*, p. 167.

This much, then, for the general theory of colour. We should now understand what colour is. Nor does it seem necessary to explain why only the one certain string of the eye builds up an appreciable oscillation under the influence of a certain series of impulses. The principle is particularly well known in music. It has been said that the continuous note of a violin at a certain pitch can develop a perceptible vibration in the Brooklyn bridge. Also, when one of the two double strings of a mandolin are struck, the other, because tuned to the same pitch, quickly builds up the same wave-beat, and soon a perceptible oscillation is to be seen in it also. Other strings with different natural periods of vibration, however, will not be appreciably affected. They receive the same amount of energy as the "tuned-in" string, but their vibrations will not grow to an appreciable magnitude because the energy of the first wave-impulse will not be supplemented in them by the second wave-impulse. When strings have different natural vibration-periods from the one giving out the energy-waves, the successive impulses which they receive will partly oppose and cancel one another.

If the eye were like a harp, the colour "red" would be the sensation realized by the mind when the bass string (the one of large mass and with the slowest period) was vibrating appreciably because in harmony with the incoming wave-impulses. The colour "violet," in turn, would be the sensation delivered by the extended vibrations of the smallest string of this harp—the string that naturally vibrates harmoniously with the highest of the visible frequencies. The colour "white", however, the composite, would be sensed when energy-waves with so many different frequencies arrived that all the strings of the harp were simultaneously responding. The colour "white" probably represents the mental effect derived from brushing the hand quickly across all the strings.

Thus, while the colour-sensation depends upon the frequency of orderly energy-impulses spread through duration, nevertheless, in order to create vision the energy-impulses must accumulate upon the strings which they affect. Only a certain range of frequencies is visible, for the strings of the eye are limited in number. And, too, when the energy-waves are too narrow-fronted they will pass between the strings of the eye without contact, without sympathetic vibration in any of these strings, and, therefore, without colour. The colour-sensations may be received only if the light-waves have a certain minimum width of structure. And yet, since colour corresponds with frequency, the shade of a colour will not alter as the intensity of its light changes. As light grows dimmer, the light-effect fades, but it always remains the same shade, just as the pitch of a musical note is the same however sharply or gently the string may be plucked. We shall continue this discussion in the following chapter.

CHAPTER XXX

THEORY OF LIGHT AND QUANTUM THEORY

In so far as reality is a cosmos or universe, and not a chaos, it must be sustained by one ground—a cosmic order-of-orders. And, since the universe, as we live in it and know it through living in it, is dynamic, the cosmic principle or ground of order must be a dynamic or active principle.

If there be any truth, the existing objects to which truth makes valid and siginficant reference must possess the specific character which makes truth valid and significant.

Ultimate reality, then, must be duality-in-unity—cosmic thought whose object is the cosmos.

Since there is change there is agency.

Scientific laws are statistical averages for the modes of behaviour of large numbers of individuals.

JOSEPH A. LEIGHTON.

THE physicists believe they have been proved that the relative velocity of starlight in collision with the earth is invariant. This proof is not final, but, whether or not it is sound, the least frequent of the recognizable light-impulses, when of ordinary breadth of wave-front, at whatever velocity they may be moving, give the series of blows known as "red", and the most frequent (at the opposite end of the spectrum from red) give the effect of "violet". The wave-lengths of the visible frequencies vary from about 39 millionths centimeter to about 76 millionths centimeter. The invisible wireless waves, Hertzian electric waves, and infra-red radiations are all longer (less frequent) than the visible waves! but the ultra-violet radiations, and both Roentgen and gamma rays, have waves shorter (more frequent) than the visible range.

Sunlight is composed of the radiations from the incandescent gases of the elements of the sun. Since the different colours develop different angles of refraction when they pass through a glass prism, and different angles of diffraction as they rub by the edge of a slit, sunlight may be decomposed and separated into its different colour-parts. It is found that each incandescent element has its characteristic shade, and, normally, its characteristic angle of diffraction. The screen made from the colours of the mixed light coming from the gases of the different elements is called the spectrum. The positions of the different shades on the spectrum, are supposed to be related solely to differences in their frequencies. Let us consider now why the bending of light-rays by refraction or diffraction *is,* at least to some extent, proportional to frequency.

If only one single wave-front of red light were permitted to pass the edge of a slit, this one wave would not appear "red" to the eye, for a series of orderly blows is necessary for the sensation of colour. This question now arises: Will a single wave bend the same amount around the edge of the slit as a series of waves, or does diffraction depend upon frequency? Is it a phenomenon of the composite? If the sensation of colour is due to frequency, if colours of the highest frequency have proportional amounts of bend, then the amount of bend, one would think, must be proportional *solely* to frequency. Certainly the amount of bend is not proportional to the intensity of light, for dim red light bends to the same angle as intense red light.

Bending, however, might be due, in part at least, to a different principle. A light-wave might have a transverse width proportional to the frequency of its emission, and the diffraction of light might be proportional to this width. Bending would then be only indirectly proportional to frequency. If, however, the bending of light-rays varied with the width of wave, the single wave would bend the same as a series; and waves near the source would bend less than waves farther away, and sufficiently delicate experiments would disclose these facts. If experiments on the single wave were possible we could determine definitely whether diffraction was thus proportional to frequencies or to the transverse width of the unit-wave. We do not find, however, that the angle of bend is changed by distance from the source of light. Also another experience seems to prove that the amount of *bend* is, at least in some respects, proportional to frequency. When the earth moves towards a star the frequency of the light-impulses from the star is altered by this relative motion—but surely not the width of the wave. Nevertheless, at such times the bending of the light increases. We are therefore lead to the conclusion that diffraction is proportional to frequency.

We must now ask how it might be that a series of waves should bend more than the single wave characteristic of the series. How can the bending of one instant depend upon the waves that precede or follow? How can the past or the future thus affect the present? Let us consider this question.

A series of waves preceding the wave of the present has an effect, not upon the action of the later wave, perhaps, but upon the structure of the slit around the edge of which the light bends. In this way the earlier history does influence the diffraction of the present instant. Not only is the structure of the edge of the slit affected unusually by the earlier light-impulses, but it should be affected in proportion to the number of these impulses. The retina of the eye (itself a material structure) is affected similarly by the wave-frequencies of light. If, therefore, a light-series is ''red'', the elasticity of the structure composing the edge of the slit has been affected by the energies of the preceding waves so that it now gives to the ray the amount of bend that red light normally displays. And, if the light-series is ''violet'', with its greater frequency (and, therefore, greater energy on a unit of cross-section), the edge of the slit will be more compressed and will therefore be more resistant, and will be capable of giving a greater bend to the ray of violet light. This might well be the explanation of the fact that diffraction, at least in part, is proportional to frequency.

We need not go deeply into this theory. The different effects of different frequencies on the structure of the slit can easily be comprehended. We must remember, however, that, according to Planck's theory, the unit of radiant energy from atomic structures is invariably a quantum of energy. According to this theory, as usually understood (although this phase of it has not been demonstrated), the quantum-delivery of energy is not affected by relative motion. According to it, when we consider any one light-series of unit cross-section, its energy-delivery will be directly proportional to its frequency, and to this alone. Mr. Luckiesh writes: "Thus, the elementary energy quantum of blue light is nearly twice as large as that of red light because the frequency of the former is nearly twice as great as that of the latter."[1] Again he says: "The number of quanta of violet light required to do the same amount of work (as red light), that is, to raise one pound a height of one foot, would be half as great; and so on."[2] According to this, violet light from a star through extended time delivers approximately twice the energy of red light to a *unit area* (unit area being here defined as the area of that unit of material structure which receives and, in turn, delivers by deflection that particular energy-impulse known as light) of the structure of the slit.

Let us suppose that some backed-up object is receiving the (in the average) centralized blows of a series of elastic volumes being impelled against it—volumes like balloons that appear to us as self-contained wholes but that really are composed of smaller parts knit into a structural whole through symmetrical energy-relationships. These balloons, we may suppose, are unusually compressed as they begin to radiate along certain direction-lines from a small source of unusual energy-emission. Millions of them shoot out in millions of directions, but each that moves in a certain radial direction is followed by another moving approximately in the same direction. As they proceed they constantly represent self-contained energy-wholes. The movement, however, is not entirely radial, for, as the elastic and compressed energy-volumes leave the source, they obtain more elbow-room from others (equal volumes of unusual energy-expression) following near-by radial paths. Each, therefore, as it proceeds, tends to expand sidewise, and to grow larger as the distance from the source increases. Nevertheless, the expanded volume contains no more of the unbalanced energy than the more condensed volume nearer the source, and it can therefore deliver no more momentum than this original amount to any resistant object which it later strikes. If the more condensed energy-volume contains a quantum of deliverable energy, so also does the expanded energy-volume. Such an energy-condition, we believe, presents a fair analogy to the light-energies emitted from some source-point, although, as we view it, the energy-volume of a certain light-impulse does not really move through inter-world space as a balloon-like and expanding projectile, but proceeds rather as an unbalanced energy-wave, the unbalanced energy being repeatedly transferred from one part of the inter-world fluid to another. This unusual energy-wave, moreover, is controlled as to its width by the range of oscillatory motion that is permitted the material object which composes it; and it is the range of movement of this material part which we must think of as enlarging as the diverging directions of the different unusual energy-movements permit increased elbow-room as they separate from one another along radial lines.

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[1] M. Luckiesh: *Foundations of the Universe*, p. 167.
[2] *Ibid.*, p. 170.

It is perhaps easier for us to visualize the situation, however, if we continue to think of the invariant energy-quantity as being transferred through space by a series of elastic balloon-projectiles which expand as they are permitted to do so by their neighbours also expanding. Yet, the most important considerations are these: Each of these self-contained energy-volumes represents a constant amount of unbalanced energy which, in the average, it will deliver as a whole to any object capable of resisting its motion unusually: This unusual energy will all be delivered by the piece of matter that then controls this width of energy-wave: And, finally, *in the average,* the piece of matter may be regarded (for practical purposes) as if in the centre of energy-wave. The energy of the whole wave will be delivered by this bit of matter to an area of approximately the cross-section of this bit of matter.

Now, if our theory is sound, the momentum of a single energy-wave is the unit of radiant energy, and it will be delivered along a certain direction-line of radiant energy-emission to an object of a certain maximum size—let us say the electron. According to this hypothesis, this same unit, or quantum, of radiant energy (providing its relative velocity is invariant), will be delivered to some small structure in its average direction-line whether this structure be a thousand or a billion miles from the source. For this reason, the total amount of energy delivered to the structure, in the average, by a certain emission-series of radiant energy at a certain relative velocity will be proportional solely to the frequency of such emissions along this direction-line, and will not be directly proportional to the distance from the energy-source of the small object which absorbs the energy. We have here described the situation that seems to explain the constant deliveries of quanta of energy to electrons by invariant velocity radiant heat and light, whether the source of light is near or quite distant, or whether the light is intense or quite diffuse. We shall return to the quantum-phenomenon later in the chapter. This development of the corpuscular theory was necessary that we might understand why light of a certain speed and with a certain colour, whether intense or faint, always appears to display the same angle of diffraction as it passes by the edge of a slit.

The total amount of energy that a series of light-waves will, in the average, deliver to a backed-up and therefore unusually resistant object, then, like the electrons composing a permanent part of the edge of the slit around which the light bends, will be proportional to the frequency of the light-waves, provided that, as usually postulated, the velocity of the light-energy relative to the struck object is invariant. If, however, the relative velocity of the light-waves from stars to objects on this earth is not invariant, the total energy-delivery to the electron of the structure of the slit will be proportional *both* to the frequency and to the relative velocity of the light-waves. We should expect the angle of diffraction of starlight to vary proportionately with changes in both these factors.

The *intensity* of the energy-delivery of a certain kind of light, however, in so far as it pertains to a generalized earth-object (as, for example, to the retina of the eye), will vary in a proportion to the density of the energy-waves of a certain kind that strike the object. Since, however, each average light-wave has a width of front which is inversely proportional to the square of its distance from the source of light, the density and the intensity of the energy of the light will become proportionately less in the same ratio. And when the distance becomes so great that the energy-delivery to the retina of the eye by light-waves of any frequency is so little that our minds cannot detect the nerve-tingle, we will no longer be aware of the light. Yet, if we expose a photographic plate for a sufficiently long time, we can take clear pictures of light-sources which give our eyes no appreciable sensation.

We now come to the heart of our theory of diffraction. We believe that diffraction is proportional to the average energy-delivery along one only of the average radial direction-lines possible to the light-emissions. That is to say, it is proportional solely to the energy delivered to an object of the struck formation which, in so far as the delivery of light-energy is concerned, is the unit of area. The amount of (unusual) compression of the struck object in its structural formation is also proportional to its receipt of this unusual energy-delivery, and, therefore, its elasticity (so-called) and its ability to refract light-rays (but not the colour-effect) vary with this energy-delivery to unit area. If, therefore, the relative velocity of the light-energy moving between worlds is indeed invariant, as some claim, diffraction (like colour) will be proportional solely to frequency, whereas the brightness of light will depend also (and more importantly) upon the intensity of the light—that is, upon the amount of energy delivered to a relatively large area.[1]

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[1] In general, an object will accumulate the ability to resist the penetration of a projectile in proportion to the duration of the period of composite aggression by the projectile, for the cohesion of a structure (that which gives it elasticity and the power to resist aggression) is not a quality inherent in the matter of the formation in question, but is a force of resistance that is obtained little by little from the environment. This exterior power is the principle that restores disarranged parts to their normal, or average, state of balance in all structures which retain their identity through time, and this power of restoration as obtained from the outside is received through time in granular increments. In this respect it is similar to the gravitational force of

Now white light, when diffracted, breaks up into the multicoloured spectrum. This is so because each light-frequency of the composite (all parts of the composite having the same relative velocity) bends to its own typical angle. The diffraction itself, however, does not perceptibly change the frequencies, for, as Sir Isaac Newton discovered, diffracted red light still remains red. Nevertheless, the emanations from the incandescent gases of the elements do have typical frequencies (and colours), and, therefore, they do bend to take fairly typical positions on the spectrum. The spectral positions appear to change, moreover, with the relative velocity of the source of light towards the earth. Is this change of position, however, due solely to frequency-changes, or are they partly due to changes in relative velocities? Is the velocity of light really invariant, after all?

When, for example, a star is approaching the earth, and is perhaps then moving through the inter-world fluid (which we can perhaps assume is stationary in respect of the earth), as might be possible according to the corpuscular hypothesis, the spectral line of every element in the star does, for some

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weight. And, for this reason, a swift bullet can drive deeper into an object—and with less damage to itself—than a slower one with the same momentum. The swifter and lighter bullet can penetrate a structure farther than another which is slower, longer, and heavier, even though each has the same diameter and the same momentum.

These facts prove that our theory of cohesion is sound—namely that cohesive resistance is received by an object from the surrounding volumes, that it is received in granular increments, and that it is derived from the blows of invisible and discontinuous corpuscles. When a very swift bullet strikes an object, the energies of the compressing corpuscles of the environment do not accumulate with sufficient rapidity to restore the disarranged parts of the structure of the object before the next unit of momentum is delivered. For this reason the object cannot offer continuously its normal resistance of the beginning to the passage of the bullet. Some of the oscillating parts composing the structure of the object are knocked unusually to one side by the first delivery of momentum by the parts of the projectile, and these (if the motion of the projectile is fast enough) will not return to their normal positions of the beginning in time to offer normal resistance to the next unit of momentum delivered by parts of the bullet. The swifter projectile thus receives less resistance to its passage through the structure because there is less time during which the parts of the struck object can be restored by the exterior forces to their normal positions.

This theory may be easily illustrated: If two swift bullets follow each other very closely into a pond, the second will find empty the path in the water as made by the first. The water, therefore, will offer less total resistance to two of such bullets following each other closely than to the same two bullets farther apart. It will also offer less resistance to two swift bullets than to slower ones with equal diameters and momenta, for as we have said, just as it is with the water of the pond, time is required that the parts of the structure as abnormally disarranged, may be restored to their normal positions.

reason, shift towards the violet. When, however, the star is retreating, the shift is towards the red end of the spectrum. This principle can be established by reference to the light from binary stars, one of which is moving towards the earth while the other is moving away. Now, it is conventionally believed that this spectral shift is due solely to the change in the frequency of the arrival of the light-waves at the earth—a frequency-change that is occasioned by the star's relative motion. It is not believed that the motion of the star towards the earth in any way affects the relative velocity of the energy-movement towards the earth, or the total amount of light-energy delivered to the earth. Science believes it has proved that the relative velocity of light in inter-world space is invariant; but, of course, this may be an error. We believe it is.

It is easy to understand why the frequency of the arrival of light-waves at the earth will be increased by the movement of the star towards the earth through a medium at rest in respect of the earth. This change would be anticipated in accord with either the ether-wave or corpuscular theory. It would be true even if the energy-waves travelled through the inter-world medium at invariant speed—and even if, as we suppose, the moving parts of the medium itself conveyed the energy from one part to another.

If a boy was approaching the bank of a lake in a boat, while dropping pebbles into the water at regular intervals, then, even though the waves from these pebbles travelled through the water at the standard speed of water-oscillations, more waves would reach the shore in a certain time than would arrive were the boat anchored. The frequency of the wave-receipt at the bank increases as the boat (the source of the waves) moves towards the shore, and diminishes as the boat moves away from the shore. A similar principle applies to light-waves.

Let us, however, consider a second possibility: When the boat moves towards the shore through water which is stationary with regard to the shore, merely the frequency, and not the velocity of the wave-approach, is changed by the relative motion. In comparison, however, when the boat containing the boy is anchored, and a second boat approaches it, the waves made by the boy in the anchored boat will strike the sides of the approaching boat with greater frequency, with greater relative velocity, and also with greater energy. Even though the velocity of the wave-motions through and in reference to the water are not changed by the movement of either of the boats, the waves will slap against the sides of a boat approaching through the water with greater force than against a stationary object, for the blows of the waves will be delivered with greater relative wave-velocity.

If this analogy applies to the phenomena of light,—that is, if the corpuscular theory of light is sound,—both the relative velocity of the blow of light and its frequency should increase when the earth, like the second boat of the illustration, begins to move towards a star emitting light-waves. This is true, however, only provided also that the earth is moving relative to the general centre of the corpuscular fluid floating both earth and star, and that the star is then stationary with regard to this medium. If conditions should be otherwise, if the earth, like a boat anchored in the lake, is stationary with regard to the filler-fluid, then the movement of the star through the fluid towards the earth will not increase the relative velocity of the striking starlight, but only its frequency.

Now, if both frequency and total energy of delivery are increased by the relative motion of star to earth, we should, according to our theory of diffraction, expect a double shift in the spectral lines when the approaching star (not the earth) was moving relative to the inter-world fluid. One shift would be due to the increase in total energy-delivery due to the increase in frequency, and the other would be due to the increase in the total energy-receipt from the increased relative velocity of each of the more frequent waves. If, however, frequency alone—and not total energy-delivery against unit area—controls the amount of bending, we should expect a smaller shift of the starlight when the earth is moving towards a star which is anchored in respect of the inter-world fluid. This shift should be proportional to change of frequency alone. We here encounter a question of fact and theory. But the possibilities of the corpuscular theory have not yet been exhausted.

The boat making the waves in the fluid medium (the star), and the rear boat receiving them (the earth), might both be moving with equal velocity away from the shore of the lake. In such case the waves would reach the second boat with normal frequency but with greater than normal relative velocity. If the light-waves performed as water-waves do, a spectral shift could then be expected even though the distance between the two bodies remained constant. According to the corpuscular theory, therefore, a spectral shift *does not prove that the distance between earth and star is being altered.*

And still another possibility suggests itself: If the first boat (the star) were moving away from the shore faster than the second, there would be a decrease in the frequency of the waves reaching the second boat, but an increase in their relative velocity of contact. The two results would thus tend to offset each other either partly or wholly. The total energy-increase as expected from the greater relative velocity of contact would be lessened by the reduced frequency. Thus a star might separate from the earth and no spectral shift would necessarily evidence the fact. Or, again, the first boat (the star) might be moving towards the second boat (the earth) while the latter was moving in the same direction and at the same speed, and, therefore, with no separation. In such case the waves would be received at the second boat with normal frequency but with reduced relative velocity, and the shift (if shift is truly proportionate to the total energy of contact of a series of waves striking unit area) would show a separation when there was none.

And a false interpretation would again be offered by the conventional theorist when both boats were moving through the fluid medium in the same direction, and when the first (the star) was following the second (the earth) but moving slower and therefore separating from it. Both wave-frequencies and relative velocity would be lessened in such case, and the shift would be greater than that which might be expected from the point of view of him who thought shift was due to change in frequency only, and that relative velocity was invariant.

Now, obviously, we cannot decide from observations whether the spectral shift of starlight is due entirely to frequency or to the total energy-delivery to a unit of cross-section.[1] When a shift occurs we cannot be sure that it is due solely to the effect that the relative motion of star to earth has on the frequency until we know more of our physical facts than to-day we do. If shift is truly proportional to the amount of energy-delivery against unit area, the bending will be affected both by frequency and by relative velocity. This *must* be the result if light is transmitted by a material fluid as we claim.

The stars are too far away for exact observation of their movements in respect of the earth. Nor can their motions relative to the inter-world fluid be precisely determined. And as to binary stars, we can tell from spectral shifts only how they move with reference to each other, and not whether the group as a whole is moving towards or away from the earth, or how it is moving with regard to the inter-world fluid. A theory of the cause of spectral shifts may perhaps be tested, however, in the relations of earth to sun, for we know the shape of the earth's orbit and her relative orbital movements. In passing around the sun the earth first moves towards the sun with increasing orbital velocity and then away with diminishing speed. Let us investigate to see whether the corpuscular theory of light can in any way be verified or disproved by the spectral shifts in sunlight as the earth revolves in her orbit.

Even before we begin to investigate the bearing of our hypothesis upon these phenomena, we learn that the conventional theory does not explain the spectral shifts of sunlight as the earth's relative velocity changes. There are mysterious *extra* shifts, unaccountable according to the old theory, and entirely unexplained until Professor Einstein advanced his Relativity hypothesis. Indeed, the ability of the Relativity hypothesis to account for these unexpected shifts in sunlight (phenomena impossible according to the classical ether-wave theory) has given it supporters. It should therefore make us more confident of the soundness of our corpuscular hypothesis if we find that it, too, affords an intelligible explanation of the extra shifts of sunlight without recourse to the supposition that Time can be altered by relative motion.

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[1] If the shift was of large proportions we might by means of it demonstrate the facts, because, according to the corpuscular theory that part of the shift which is due solely to changes in relative velocity of the energy-wave, would have no effect on the colour of the light, but would affect only the angle of the bend. According to the corpuscular theory we should expect to be able to find identical shades of colour in two different positions on the spectrum. The result would depend upon the relative velocities of the light-waves. Two waves arriving with identical frequencies would give the same colour-shades, but they might have different relative velocities, and, therefore, different angles of diffraction.

A spectral shift towards the violet end of the spectrum proportional solely to the change of the light-frequency would be expected with relative motion of sun to earth on the assumption that the inter-world fluid is stationary in respect of the earth and that the sun is moving through this fluid towards the earth while emitting series of light-impulses. And according to the corpuscular theory there would be a double shift towards the violet if the sun were anchored in respect of the inter-world fluid while the earth was moving through this fluid towards the sun. Yet the corpuscular theory does not carry the assumption that the earth is thus moving through this fluid. And, moreover, this mysterious extra shift is of neither sort. We do not obtain the expected shift towards the violet, nor the double shift; but, rather, there is a single shift towards the violet which is less than the conventional theorist would anticipate. And again, when the earth is moving away from the sun the extra shift appears also as a shift towards the red in addition to that expected solely from that change in frequency which is due to the relative motion. These extra shifts (both towards the red) must be explained in terms of any proposed theory that is to be acceptable. If this cannot be done, either the theory is wrong or else some of its implications have not been understood. An explanation of these extra shifts of sunlight has been advanced in terms of the remarkable assumption of Einstein that Time (Time being regarded here as a factor having a controlling relationship over energy-delivery) can be changed by relative motion.

While the extra shifts are so tiny as to be almost immeasurable, and while they are therefore almost indemonstrable, they nevertheless appear to be actual.[1] We who deny the assumptions of the Relativists are inclined to admit the reality of these extra shifts for two reasons: Firstly, because they appear to have been proved, and secondly, because the shifts should be expected by one who accepts the corpuscular hypothesis here being advanced.

On the other hand, Professor Charles Lane Poor, who does not accept the Einstein theory, and who relies upon Newtonian principles, cannot explain the extra shifts. Hence he is inclined to deny their reality. Thus he writes:

> Now Einstein has shown that, according to relativity, there should be an additional shift of the lines in the solar spectrum towards the red end of the spectrum. This Einstein shift is extremely small; the shift for each line being proportional to its wave length and amounting to about the two millionth part thereof. Thus, in other words, if the sun be approaching the earth, then the Einstein shift and the motion shift act in opposite directions and the total shift will be slightly less than that due to the motion alone; while if the sun be moving away from the earth, then the Einstein shift would be added to the motion shift, and the total would be slightly greater (greater towards the zone of lesser shift) than that due to the motion alone. Thus the Einstein shift, if there be such a thing, is all tangled up with the shift due to relative motion of the sun and earth; it is extremely small, is at the very limit of measurement, and can only be detected with the most powerful modern instruments and with the utmost refinements in method and care in making observations. So different are the measurements and so surrounded by disturbing factors, that it seems hardly possible that a conclusive result can be obtained.
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> Some indications of an Einstein shift have been found by certain observers, but the shift so found, if

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[1] It has not been proved, however, that a change occurs in the colour-shade corresponding with this extra shift of position—see preceding foot-note.

> real, does not agree in amount with that required by the relativity theory.[1]

Most astronomers, however, accept the fact that there are these unexpected shifts of sunlight towards the red end of the spectrum. It should indicate, therefore, that some influence heretofore unrecognized is constantly subtracting from the expected energy (rather than from the frequency) of a unit series of light-impulses coming from the sun. On the assumption that diffraction is affected by the total energy of a unit-series of light-impulses, and that this energy, in turn, is affected both by changes in frequency and by changes in the relative velocity of the light, the explanation of these extra shifts can readily be had in terms of the corpuscular hypothesis.

According to the corpuscular theory of gravitation, the earth as it moves around the sun is being impelled by two energy-currents. The earth's orbit (and both earth and sun according to this theory may be regarded as relatively stationary to the current) would be circular except for the fact that there is another effecting energy-current focussed on a very distant point. This, like a gentle sidewise breeze blowing always in one direction, makes the earth move faster as it approaches the closer perihelion-point, and equally retards her motion as she moves away from the sun towards the aphelion-point. According to the corpuscular hypothesis, this sidewise breeze—an influence which is not considered in the classical ether-wave theory of light—should have an effect on the relative velocity of light-impulses travelling through the otherwise stationary inter-world fluid between sun and earth, and this effect, in turn, should produce this extra shift towards the red which Einstein attempts to explain in terms of the Relativity-hypothesis. It is not difficult to understand that this additional energy-current (acting approximately in a direction parallel to the line connecting the perihelion with the aphelion) would be an energy-influence that must be subtracted from the energy-impulses of sunlight moving towards the earth whether the earth is then moving towards or away from its perihelion. The relative velocity of approach of the energy-waves of sunlight towards the earth should, therefore, according to the corpuscular hypothesis, be less than that expected according to the classical theory. Since, however, the corpuscular theory has indicated that diffraction is also affected by changes in the relative velocities of the energy-waves of light in respect of the struck object, and has indicated, too, that the relative velocity of such energy-waves is not invariant, we who have faith in the corpuscular theory should expect these extra shifts towards the red end of the spectrum. We do not require the Relativity assumptions to account for this happening. Indeed, if the explanation according to the corpuscular hypothesis is sound, the explanation advanced by Einstein cannot be sound. Nor is the Relativity theory needed to explain the rotation of the perihelion of Mercury, for, as already suggested in earlier pages, the corpuscular theory leads one to anticipate this happening also.

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[1] Charles Lane Poor: *Gravitation Versus Relativity.* pp. 58–59.

Einstein made use of his Relativity hypothesis, however, to predict a light-phenomenon which at the time had never been encountered. This phenomenon, moreover, was contradictory to the anticipations of the classical physicists. He asserted that light-rays passing close to the sun would be curved more than would be the case according to Newtonian theory if light were a material projectile influenced by the gravitational attraction of the sun. The curvature, he said, should develop from the passage of the light through curved space-time—the space-time in question being curved (to relative motion) both by the presence (the normal gravitational influence) of the unusual mass of the sun (at a distance, of course) and by the presence of the centre of the general mass of the finite universe. These influences are entirely omitted from the classical ether-wave-theory of light.

Attempts to verify or to disprove the prophesied gravitational and *extra* curvatures of starlight passing the sun were made a few years ago at the time of an eclipse of the sun, and aroused much interest. Although there were minor differences, the astronomers then, and again more recently, agreed that their photographs disclosed bending of starlight passing the sun—even more than could be expected from the influence on a light-projectile of the gravitational force of the sun alone. The verification of Einstein's prediction—this proof of a fact regarded by some as the supreme test of correctness of his assumptions about variable Time—naturally brought him many followers.

Now it cannot be denied that Einstein prophesied,—and used his hypothesis as a basis for anticipating,—one phase of a physical happening heretofore misconceived and incorrectly described; but the important question still remains: Has he advanced the right explanation? Merely because there is this unexpected bending of starlight near the sun does it necessarily follow that Time may be altered by the relative motion of starlight, that space-time may be curved by the distant presence of unusual mass-density, and that space and time are factors in energy-phenomena? Does this unexpected happening of the open spaces, not normally experienced or known empirically, call for our unqualified acceptance of metaphysical concepts which our minds naturally incline to reject because our reason pronounces them inconceivable? The extra bending is contrary to Newton even if light were a projectile with mass, but must we thus hold with Einstein? Must we assert, indeed have we any right to assert, that the power which has thus unexpectedly curved light-energies as they pass through extended space and time, is altogether a mechanical power? Shall we be justified in thus denying all mental qualities and powers as factors that might create mechanical change—even in the movements of the smallest masses through the widest reaches of the universe? Certainly, if a spiritual Cause can have no influence here in these most delicately balanced and most easily affected of all the known mechanical relationships, there is then no place for spirituality in the world as we sense and know it, and there is no possibility of a reconciliation between Science and Faith—and Science has no Spiritual Side.

It appears that Einstein (and most of his followers) still believes that the physical circle of relationships is perfect, that the chain of mechanical cause and effect is invariable, *and not to be varied* by any known influence now entering into those mechanical relationships which give man his sensations and his life. The Relativity hypothesis is an attempt to maintain this materialistic position in the face of evidence that a spiritualist might accept as meaning something quite different. Einstein apparently believes that the principle of mechanical Conservation applies perfectly to the passage of light-energy through inter-atomic spaces, and his hypothesis (or assumption, as it were) purports to explain, in terms of Conservation, happenings that at the first glance (and also to the more prolonged scrutiny of some persons) might seem to conflict with pure mechanism. Is it necessary, however, that we agree either with the old or the new mechanics? Must we be completely mechanistic? I do not think so.

The corpuscular theory follows neither concept. It recognizes the validity of the mechanistic principles in certain physical relationships, but completely denies them in others. It is based upon the belief that the world represents a changing dualism—mind and matter—each with its distinctive attributes and definitions. It is conceived also that the two parts influence each other, for one is active, and the other, because passively inert, is resistant to activity. Indeed, the mental or spiritual power is defined as being without physical inertia-properties whatever; and the influence of this non-material part of the universe as an active agent creative of the motion-aspects of mechanics, is both proclaimed and identified.

Beginning with certain definitions, we have finally arrived at a corpuscular theory of gravity, and at the concept that there is a general pool of moved bits of matter between which there exists a created energy-harmony-or-equilibrium. We thus offer an unmechanical explanation of the basis of mechanics. This theory rejects mechanical Conservation. It also calls for phenomena different from those that the Newtonian physicist could anticipate. To be sure, the corpuscular theory calls for the Relativity-theory amount of curvature of starlight passing the sun, but, unlike Relativity, it does not strain our sense of reasonableness by asking us to accept the idea that a curvature in the walls of a physically empty space-time (a curvature itself supposed to be caused by the presence of unusual mass at a distance in space) creates curvatures in light-rays. Einstein does not profess to identify the source of the power which, with the walls of space-time as its instrument, deflects relative motion into curves. He does not profess to explain anything fundamental. He merely changes the Newtonian formula so that it fits the new experience. He then tests his assumptions by means of certain delicate inter-world phenomena. We complain that he seems to assume that his changed formula, with changeable Time in it as a factor in energy-delivery, is still a formula representing pure mechanism,—and that this his mechanical creed has been proved. There is no justification, we think for this view. We see considerable room for argument against it.

Now, if light-energies were transmitted as ether-waves, it is not easy to see how the sun's gravitational influence could cause the least curvature of light-beams. How can gravity attract and thus deflect the motion of that which has neither mass nor inertia? How, then, can the classicists be right? If, however, the corpuscular theory is sound, the waves of light-energy move in a material fluid. This fluid, composed of locally moving bits of matter, surrounds the sun, and the energy-waves passing through it, by inter-actions of the typical bits of inert matter, respond to the gravitational influences as already described, and are curved with regard to the centre of the sun's mass. We should therefore naturally expect the light-motions to curve as much as they would if the light-beam passed by the sun as a projectile influenced by attraction. According to our hypothesis, millions of separate projectiles of inert matter take the place of the one of the standard projectile theory. The mechanical result, however, is approximately the same.

According to the corpuscular theory, the sun's negative gravitational influence is not the only deflecting influence: The curvature of light should respond to more than this. In addition there should be a general curvature due to the general gravitational ''attraction'' about the centre of mass in general, the same curving motion of moving matter in the average which keeps the universe restrained. Like Einstein, then, except arguing from a very different hypothesis, we presume that there should be more curvature of light-rays passing on one side of the sun than might be expected from the gravitational influence of the sun alone.

We can conceive of no meaning that might be given to the statement that the space outside of the physical matter-particles is real mechanically, or that it can of itself influence mechanical phenomena. We cannot conceive that such exterior space, or physical void, can have its walls curved so as to have mechanical effect. We cannot understand how this void can be influenced by the relative motion through it of a corpuscle, or of an energy-wave in ether, or by changes in space-time, or by the presence of anything that resides in, and that therefore is a property of, any distant mass. We can understand, however, how the average energy-motions of bits of matter *through* space might be everywhere deflected, and thus restrained, by the will of a power transcending mechanics—and using other moving matter-bodies as its instruments for carrying out its will. When thus influenced and moved, we can understand why matter in general curves about the general centre of mass.

The corpuscular theory is founded upon suppositions involving positive mental accomplishment. In this respect it is the reverse of all interpretations of mechanical events based upon pure mechanism. It is founded upon suppositions which do not exclude but rather demand the presence of a positive spiritual influence. It does not deny the power creating Change, but accounts for Change in terms of Purpose accomplished. It thus seems to us more satisfying mentally than the unexplained Relativity-additions to the classical picture. It supplies us with more explanations. It synthesizes more of experience. It identifies the part that mind plays in the mechanics of the universe; and thus it is able to explain the reason for, and point to the power behind, the cyclical motions that everywhere obtain.

The corpuscular theory of light is supported also by the fact that it is impossible to concentrate a few light-rays (rays that are not emanating in *all* directions from a source) more than a certain maximum amount. Even if such rays are focussed by parabolic reflectors, they refuse to converge indefinitely. Thus they follow, *in the average,* the laws of waves in the typical matter-pool. A few streams of water shot together will not produce a water-density much greater than normal, and any unusual density that is momentarily obtained will not long continue. By subscribing to this principle, streams of light display their material properties. Light-energies appear to be similar to the energies that would be delivered to the water of a pond by a million water-jets emitted from a focal point underneath the surface of the pond. But we should note that, even if there were millions of these jets, there would not be enough of them to start in the direction of every point on a distant shore of the pond. This must be so, even though, finally, every appreciable point of the shore seems (to a gross observation) to be affected by these energy-emanations.

It was once thought that radiant energy emanated from its source in an infinite number of directions, and that the wave-front of light was continuous. In developing his electromagnetic theory of light, Clerk Maxwell did not depart from this idea of continuity and homogeneity, although he did explain the spreading on a somewhat new basis. Now the energy of light does spread, but it reduces in *averaged* intensity as it proceeds. When the intensity of light at some distance from its source is regarded in generalized fashion,—that is, when it is averaged rather grossly in terms of space and time, so that the entire area of cross-section in which a certain light-beam *might* be encountered, is considered as a whole,—it is found that the light-energy spreads into the neighbouring volumes as it proceeds. The wave-front of the unusual light-energy (and we mean here by "wave-front" that area of cross section which contains the unusual energy of a single light-emission or light-beam) spreads as it leaves the source, but each wave-front as a whole still contains only the same proportionate part of the total light-energy that it exhibited when closer to the source, and when it was therefore less wide. As the energy of starlight spreads, as the diameter of the spherical area which it *may* affect, enlarges, the intensity of the light as delivered against a certain generalized area diminishes, as we have said, in an inverse proportion to the square of the diameter of the sphere. We do not mean by this, however, that every point on the surface of this imaginary sphere can receive part of this light- energy, or that every part of the wave-front can deliver it. Far from it! The entire wave-front cannot give out light-energy in the sense that all points of its cross-section can deliver light-energy simultaneously. Only one part of the wave-front can deliver the energy of the wave. Nevertheless, if again we wish to generalize grossly, and if we wish to average the possibilities through a relatively long time, there is some truth in the assertion that any part of the wave-front *might* deliver energy. Yet the fact remains that one part of the wave *must* deliver all of it. The principle is easily illustrated.

If a person inserts a stick between the rapidly revolving blades of a fan, then, wherever the stick may happen to penetrate the blade-controlled area, it is certain that it will be struck by one of the blades—provided that one waits long enough. This, however, does not signify that the fan blades express energy continuously throughout the whole of this blade-controlled area. Indeed, if the fans were revolving with inherited momentum (and this represents the condition of light-energy after it has left its source), only one blade, in one particular location, at one particular time, will deliver a blow to the intruded object. The concept that at one instant the entire fan-blade-area is capable of delivering energy to one intruded object, or that after part of the energy has been delivered by one blade there still remains the full amount to be delivered by another one, is, in such case, clearly erroneous. And the further concept that such energy-delivery can continue at full strength for any duration of time is also erroneous. It is true, of course, as a matter of general practice, that whenever a stick is shoved between the revolving blades it will *finally* receive a certain amount of energy; but this belief is well-founded only if the time during which the stick penetrates the blade-area is sufficiently prolonged. A bullet can be shot through the fan area without touching a blade. Yet physicists in the past have made the unreal assumption that light-energy was uniformly spread over its wave-front, and that the wave-front of light could deliver its energy over a continuum. They have regarded light as the wave in an imponderable continuum possessing the ability to express wave-energy simultaneously everywhere throughout the wave-area.

The unreality burdening our concept of gravitation has distorted the concept of light. Both forms of energy have been regarded as continuous *in* time and space although both are known to be limited *through* time and space. This view has been based on a concept philosophically impossible. Although irrational (and, for this reason, we claim, unsound), it was accepted because seemingly it was supported (and, therefore, in the eyes of some, verified) by the sense-data. Recently the discovery that light-energy was not continuous has disturbed this view. It has been found that light-energy is received and emitted in quantum-granules. It therefore cannot be continuous—as the physicists are now obliged to admit. The energy of a wave-front of light must be concentrated in, and completely represented by, the separate energies of those separately moving physical objects which by their restrained motions, compose this particular wave-front of energy, and which deliver its unit energy-impulse, and which, therefore, represent all of its mechanical reality.

Every oscillating piece of matter (and all matter-particles oscillate) controls, one might say, a certain average energy-volume. This principle is true of the revolving fan, or of the range of a clock's pendulum, or of the tidal oscillations, or of the moving cross-heads of an engine. It is also true, in gross terms at least, of those restrained energy-volumes which we call stones or sticks, the formations of which are maintained through time as stable wholes by the limited forward and backward movements of their smaller parts. The smallest objects,—corpuscles, atoms, or molecules, as the case may be,—those that compose the energy-movements that are "sensed" after they have been translated through space from the energy-emitting element, are too tiny to be perceived separately, hence their energy-deliveries are realized only as composites, or as series-effects. Nevertheless, the mechanics of every energy-representation that reaches us as a sense-datum is derived from and represented in the energy-series of its separately oscillating parts.

All the mechanical properties of a pond, for example, when regarded as the qualities derived from the energy-volume recognized as water, all of the ability of the water to deflect sunlight, to float wood, and to resist compression, and even its property of being typically transformable into another type of energy-volume (such as steam, or ice), are derived from the grouped energy-deliveries of its separately oscillating atoms of oxygen and hydrogen—or of the molecules composed of these two elements. The mass-motion of each molecule (or smaller part) controls mechanically, so to speak, the line, the area, and the volume of that certain range of space through which in the average the material part moves. And the inertia-property of this piece of matter (as derived from its rigid extension within itself of line, area and volume) permits its movements to control certain extents of line, area, and volume, at least in the sense that, *in the average,* these fields of space are clear of other similar moving matter. The width "controlled" by the sidewise swing and return of the material object constitutes the wave-front of the unit of this particular energy-demonstration.

The principle of energy-control as thus set forth applies to energy-waves in all fluid media, and refers to wave-depths as well as to wave-fronts. And it is applicable, also, whether the waves are of the normal, balanced, and often unappreciated types (such as the air-pressures against our bodies), or whether they are those abnormal energy-demonstrations that afford our sensations of colour, sound, heat, or smell.

We recognize the unusual energy-effect solely through the medium of a series of *unusual* energy-deliveries. And, because these energy-deliveries *are* unusual, they are translated from one energy-volume to the next adjacent one by unusual energy-movements of the unit parts of these respective volumes, and they thus reach our organs of sensations with unusual but diminished average effects after having been spread out, by passing through long ranges of time and space, to larger spherical areas. Only the unusual energy-expression can be conveyed to us through long distances to reach us in series of still unbalanced energy-waves that may be the bases of sense-data.

The sensation-giving waves of colour, sound, etc., therefore, are derived from abnormal energies of motion that are carried forward in certain general directions by means of the mechanical contacts of the material parts of a fluid medium. The presence of a fluid medium having parts normally oscillating is the necessary postulate if we are to assume that energy is translated through space either normally or abnormally. The "appearances" of the colour or sound informs us, therefore, that the material parts of the corpuscular fluid medium (or energy-volume) that is then affecting this particular organ of sensation, are oscillating abnormally along lines which, in the average, focus (in reverse) upon the source of the unusual energy-demonstration. The amount of the abnormality of the energy-expression may often be interpreted accurately by means of a sensation. As the abnormality subsides, the intensity of the sensation will reduce correspondingly.

Now, whatever the dimensions may be of the wave-front or wave-depth in the energy-volume transmitting certain sense-data, this extension, so far as sensations are concerned, may be defined as the average range of the oscillations of that one object whose blow gives the unit effect of this particular type of sensation—that is to say, whose collision-effect, when repeated in regular series, builds up a vibratory nerve-energy that is appreciable by the mind. The wave-front is the space-range controlled, so to speak, by the average oscillation of this one object to the exclusion from this range of similar objects oscillating in adjacent energy-formations. This is the only wave-front of an unusual energy-impulse that has physical reality. Nor is any other (at least any definable in terms of the properties of matter) given reality by the space-controlling properties of the inertia that is represented in the extension of the unit of matter. No other wave-front is conceivable unless we are willing to imagine that mechanical energy can be delivered by an imponderable and non-material ether or electromagnetic field.

A wave-front, therefore, as it is defined under the hypothesis that energy may be derived only from matter in motion, is the normal range of the oscillatory movement of a physical object; and this object may be very tiny or very large. Its size depends upon the nature of the mechanical phenomenon that is under consideration. Thus the wave-front of a unit of the energy-expression derivable from the movement of the earth about the sun is the diameter of the earth's solar orbit, whereas the range of the sweep of the clock's pendulum constitutes its wave-front. The principle of energy-controlled space as exemplified in the rotating fan, or in the swinging pendulum, applies to the cyclical oscillations of the planets in their orbits, and also to the corpuscles composing the fluid that transmits light-and-heat-energy.

According to the corpuscular theory, the object giving the unit of the unusual energy-delivery of the sensation in question, is brought to rest, and then reversed in motion, within wave-fronts that will average approximately the same over areas equally distant from the energy-source. We must remember, however, that one energy-volume can simultaneously deliver several types of sensation. A piece of celluloid, for example, can deliver simultaneously the sense-data of smell, sound, colour, heat, and hardness. This is true because there are different structural formations separately moving within the energy-volume known to us as a piece of celluloid, and these different formations, all oscillating objects when taken as wholes, display different wave-fronts. Our chemical compounds are composed of separate moving material objects—moving corpuscles grouped fairly permanently into moving electrons, moving electrons probably grouped fairly permanently into moving hydrogen-nuclei, entire atoms composed of these moving parts, molecules structurally combined from moving atomic parts, and chemical mixtures or compounds of different types of molecules. Each different type of object remaining consistently within a certain structural formation, so long as it, as a whole, controls by its movements a certain extension in space as its own typical wave-front, has its own normal frequency of oscillation, and its own ability to act as a unit blow-giver of a certain type of sensation.

When referring to the unusual energy-transmission of radiant energy, therefore, we mean by the "wave-front" the range of motion of the objects delivering energy-sensation as this energy is displayed transversely to the line of translation of the energy. At a certain distance from the source of an unusual energy-demonstration, we may suppose that these wave-fronts average the same cross-section, but, as the unusual energy of the beginning is dissipated into the energy-volumes alongside by the contacts with the objects "controlling" these volumes by their respective motions, the dimensions of the wave-fronts will doubtless change.

We need not consider farther the extent of these changes. We merely wish to emphasize the fact, that, in the plane transverse to the direction of the receipt of unusual energy, there may be found, in the average, only one oscillating object whose blow is typical of this sensation. If the sensation in question is one that is delivered by the smallest bit of matter, only one of these smallest bits controls the wave-front which is the unit of this sensation. Hence, the energy-delivery of this sensation *must* be granular. This reasoning leads us to expect that the energy-delivery of radiant light would be delivered to another object, not by the *entire* wave-front of the light, but by that *one* part in which the oscillating corpuscle happens to be when the contact is made.

If, then, the blow of radiant energy as received from the inter-atomic fluid, is delivered, as we suggest, by one of the smallest objects maintaining the energy-volumes of this fluid, and "controlling" the wave-front of the light-beam, the energy-series will be received in multiples of the energy of contact of this mass. This type of blow is the only one that can possibly be delivered as heat or light by the inter-atomic fluid according to the hypothesis. It is also the only one that is received by that object which the radiant energy effects. The radiant-energy will therefore be granular, will be concentrated in a point no wider than the physical extension of the object, and will be delivered and received in multiples of the unbalanced momentum of the object in question.

We believe that we now understand why the unusual energy-delivery displayed by all forms of radiant energy occurs in multiples of the momentum of a certain granule of mass. If we can now discover why this granule of matter impinges unusually with (approximately) an invariable energy, we shall understand why the energy of radiant light and heat is received in multiples of a certain (approximate) amount of momentum—namely, that which has been called the quantum-quantity. Before attempting to give this final explanation, however, it might be well to quote from some of the more modern writers to learn how they view the problems that have been introduced into physics by the discovery of the fact that radiant energy is delivered in multiples of a certain granule-quantity—and as if concentrated in a point.

Mr. John Mills, in *Within The Atom,* writes that all radiations except heat rays (believed, he says, to be due to motions of atomic systems) and Hertzian waves (due, he claims, to surges back and forth of electrons in wire systems) are due to "vibrations of the electrical elements within atomic systems." (p. 116) Then, in speaking of different types of vibrations, he remarks that sound-vibrations are derived from systems which are aggregates of molecules whereas light-vibrations are obtained from the movements of discrete electrons. He asserts that "The restoring forces are usually due to elasticity in the cases of the sources of sound, and hence to intermolecular forces, but for light they are intra-atomic." (p. 118) He thus, without sufficient justification, assumes that elasticity may be an independent power-source —one that may restore structures through their own self-actions.

Mr. Mills considers the sound vibrations of a plucked violin string—both the receipt of the energy and later its slow dissipation, and he says: "Both the absorption and the emission of the energy are conceived as continuous phenomena, just as if there was a flow of fluid energy which is infinitely divisible." (p. 119) Yet we cannot see how this concept of continuity of sound-dissipation and of sound-receipt can be justified. As to the electronic oscillator, he states that: "Unlike the vibrating systems of mechanics, whether actual or theoretical, the vibrating systems of the electrons within an atom do not radiate energy continuously but emit it in definite quanta. According to the present accepted picture the electrons may vibrate in orbits without loss of energy to surrounding systems. (This in itself is an argument against an all-embracing ethereal medium, for if it was capable of absorbing energy at all from a vibrating electron we should expect it to do so [Mr. Mills' language, this] continuously.) When, however, there is a change in the orbital motion of an electron, then a quantum of energy is shot out. This quantum travels with the enormous velocity of 30,000 million centimeters a second, that is with the velocity of light." (p. 120)

The quantum of energy as derived from the bombardment of an atom by electrons is always the same unit quantity (h), but the frequency of the quanta-emissions are characteristic of the atomic structures which are subjected to the bombardment. If the impingements of light-rays cause the emissions of electrons from a substance, the frequency of the emissions will increase as the intensity of the light increases, but the energy of each emitted electron will remain constant.

Mr. Mills asks the question: "When an electronic system expends energy it does so in definite amounts. Is energy granular or atomic in character? Must we think of it as transmitted through space like a corpuscle? And then, is each corpuscle of energy received *in toto* by a single electron? Since an electron can emit only definite quanta of energy, can it receive energy in amounts of less than a quantum? If it receives and emits only by quanta, presumably its own total energy at any time is some integral number of quanta. What in any case is the mechanism which is involved?" (p. 148)

He then remarks that when a substance is exposed to light and the photo-electric emissions begin, "the energy which is released was either obtained from the beam of light, despite the short time of exposure, or was already stored in the atomic system. The further fact that the energy of the emitted electron is the same whether the intensity of light is large or small would seem to indicate such a storage." (p. 148) Photo-electric emissions of electrons are produced by the light from a candle three miles distant. Taking everything into consideration, Mr. Mills says: "We are forced, therefore, to the conclusions that the energy of the escaping electrons is derived from the incident light." (p. 149) Finally he stipulates that "Matter which originally appeared to mankind as continuous and infinitely divisible has been shown to be atomic. Electricity, whose phenomena appeared to be those of an invisible fluid, has proved to be granular in structure. Why should we not expect that energy also should prove to be not infinitely divisible but transmissible only in finite amounts? There are three objections: First is the incompleteness of the evidence, second the subconscious effects of our scientific traditions and training, and third, a definite piece of evidence against the hypothesis which as yet has not been explained away." (p. 151) This evidence is the phenomenon of interference. It is the same phenomenon that Mr. Bertrand Russell regarded as convincing proof that light was transmitted as an energy-wave.

In his *The A B C Of Atoms,* Mr. Russell writes: "The new dynamics of the atom, on the contrary, not merely alters our view as to what actually occurs, by leading to the conclusion that change is often discontinuous, and that most of the motions which should be possible are in fact impossible. This leaves us quite unable to account for the fact that all the motions that are in fact possible are exactly in accordance with the old principles, showing that the old principles, although incomplete, must be true up to a point. Having discovered that the old principles are not quite true, we are completely in the dark as to why they have as much truth as they evidently have. No doubt the solution of this puzzle will be found in time, but as yet there is not the faintest hint as to how the reconciliation can be effected." (p. 57)

Of the quantum, he remarks: "It is one of the fundamental constants to which science is led: for the present, it represents a limit of explanations, since no one knows why there is such a constant or why it is just the size it is. The limits of our explanations in any given stage of science are, while that stage lasts, brute facts; and so Planck's quantum, for the present, is a brute fact. It is involved in all very small periodic processes; but why this should be the case we do not know.'' (p. 71)

Mr. Russell prefers to regard the quantum as a constant of action rather than as a constant of energy-expression. Action is discontinuous. There are quantum-atoms of action. He says that it is not easy ''to suppose that any theory which was not atomic would explain the facts. But when we come to what goes on in 'empty space', or in the 'æther', we find ourselves in difficulties if we adhere to the quantum theory.'' (p. 135)

In the interference phenomena, according to Sir James Jeans, if light occurred only in quanta, there could be interference only ''at a point at which two or more quanta existed simultaneously.'' It has been proved, however, that this is not the case. However much the intensity of light is reduced, even in the case when ''an exposure of 2000 hours was necessary to obtain a photograph,'' the photographs of diffraction patterns displayed the alternation of light and dark with undiminished sharpness. ''Thus,'' quotes Mr. Russell from Sir James Jeans, ''it appears that there is no hope of reconciling the undulatory theory of light with the quantum-theory by regarding the undulatory theory as being, so to speak, only statistically true when a great number of quanta are present. One theory cannot be the limit of the other in the sense in which Newtonian Mechanics is the limit of quantum-mechanics, and we are faced with the problem of combining two apparently irreconcilable theories.'' (pp. 137–8)

Mr. Russell says that the action of the ether-wave out in empty space must be treated as a whole period-process, and whereas this ''makes the quantum principle more puzzling, it also prevents it from being inconsistent with the known facts about light.'' (p. 139) ''The quantum principle'', he states, ''in the modern form is far more astonishing and bewildering than in its older form. It might seem odd that energy should exist in little indivisible parcels, but at any rate it was an idea that could be grasped. But in the modern form of the principle, nothing is said, in the first instance, about what is going on at a given moment, or about atoms of energy existing at all times, but only about the total result of a process that takes time. Every periodic process arranges itself so as to have achieved a certain amount by the time one period is completed.'' (pp. 139–40)

As Mr. J. W. N. Sullivan tells us in *Atoms and Electrons,* when light rays impinge against a metal, electrons will be liberated, and we find that ''the *number* of electrons liberated depends on the *intensity* of the light, but that the *velocity* of the electrons depends on the *frequency* of the light. This result is very surprising. We should have expected that the more intense the beam of light the higher the velocity of the liberated electrons.'' (p. 117) ''Very weak beams of high frequency light will cause electrons to be shot out of the metal with high velocity.'' (p. 118)

If electrons in a cathode tube are allowed to knock X-rays from a piece of metal, and these X-rays in turn strike another piece of metal and knock out electrons, the velocity of the electrons as thus produced have the same velocity as the electrons which generated the X-rays. According to the physicists this is an ''astonishing discovery.'' The key to it is found in the quantum theory, according to Mr. Sullivan, but the trouble is that the wave-theory of light ''seems utterly irreconcilable'' with the quantum theory. As he says ''Neither of them seems in the least adequate to explain all the known phenomena.'' (pp. 121–2)

In *The Nature of the Physical World,* Professor Eddington tells us that ''The indivisible units in the shuffling of energy are the quanta.'' (p. 185) He does not tell us, however, what causes the shuffling-processes. He remarks too that ''the paradoxical nature of the quantum is that although it is indivisible it does not hang together. We examined first a case in which a quantity of energy was obviously cohering together, viz. an electron, but we did not find *h;* then we turned our attention to a case in which the energy was obviously dissolving away through space, viz. light-waves, and immediately *h* appeared: The atom of action seems to have no coherence in space; it has a unity which overleaps space. How can such a unity be made to appear in our picture of a world extended through space and time?'' (p. 185)

"The pursuit of the quantum", says Eddington, "leads to many surprises; but probably none is more outrageous to our preconceptions than the re-gathering of light and other radiant energy into *h*-units, when all the classical pictures show it to be dispersing more and more. (p. 185)

Although the star Sirius is fifty billion miles away, although its light-wave reaches the earth apparently eight years and nine months from the time it is emitted from the star, it delivers to our eye exactly the same type of quantum of action that the eye would have received if it had been stationed anywhere else along the route. Bluer light, light with more frequency, will increase the speed of the ejected electrons, but not more powerful light. The speed of the electrons that are ejected from earth-elements by the impact of the faint blue light of Sirius is greater than that developed by sunlight.

Professor Eddington writes: "Suppose that light-waves are of such intensity that, according to the usual reckoning of their energy, one-millionth of a quantum is brought within range of each atom. The unexpected phenomenon is that instead of each atom absorbing one-millionth of a quantum, one atom out of every million absorbs a whole quantum. . . . It would seem that what the light-waves were really bearing within reach of each atom was not a millionth of a quantum but a millionth chance of securing a whole quantum. The wave-theory of light pictures and describes something evenly distributed over the whole wave-front which has usually been identified with energy. Owing to well-established phenomena such as interference and diffraction it seems impossible to deny this uniformity, but we must give it another interpretation; it is a uniform *chance of energy."* (p. 189) He says finally that *"The classical laws are the limit to which the quantum laws tend when states of very high quantum number are concerned."* (p. 195)

Just here it might be well to note that all of the attempts to reduce matter to an equivalence with electromagnetic fields have failed. As Mr. d'Abro writes in *The Evolution of Scientific Thought,* the difficulties have been insuperable owing to "the impossibility of accounting for those ultimate aspects of matter, the electron and the proton in terms of the E_{ik} [Maxwellian stresses] alone.'' (p. 358) And then he goes on: ''Some kind of counterbalancing pressure, the Poincaré pressure, seems to be necessary, and it appears to be impossible to account for this mysterious pressure in terms of the electromagnetic Maxwellian stresses E_{ik} alone.''

The electromagnetic field with its unexplained strains and stresses is not a reality that can displace the more definite reality of matter-inertia, and the quantum-theory, which discloses energy-actions as taking place in discrete quantities, indicates to us that the matter-principle resides in discrete quantity-extensions of space, and not as fluctuating strains and stresses in an imponderable ether. The quantum-theory is at present a mystery to the modern physicists, hence they now are relying upon contradictory assumptions for their interpretations of many phenomena. Jeans, Eddington, Bragg, Russell, Poincaré, and other leading scientists of the day, paint the same picture. All admit their present inability to offer an explanation of phenomena in non-contradictory terms. Even Clerk-Maxwell was forced to suppose that the hypothetical ether-continuum (assumed to be acting as a carrier of the electromagnetic waves) contained energy of the conventional kind, but he did not attempt to identify this source, or to describe its nature.

In his address to the British Association for the Advancement of Science as reported in the *New York Times* of September 12, 1928, Sir William Bragg stated that the experiments show that light ''Has the property of a stream of minute particles. So far no existing thinker could show how the same thing could be both a wave and a particle.''

Prince de Broglie admitted this, too, but said that ''It was shown by these experiments that the electron hitherto regarded as the indivisible unit of the material universe, could be shifted by magnetic attractions. . . . The electron could expand like an umbrella when it left the atom [after diffraction from crystals] and . . . in the expanded state it might have a composite structure and was not the indivisible unit that had been supposed." He said further that ''material corpuscles, electrons for example, can afford phenomena similar to the well-known diffraction of light.'' Diffraction, therefore, is not necessarily a unit-phenomenon; and even the unit of the light-effect may itself be delivered as the blow of a composite physical structure.

In further support of the corpuscular theory we refer to the statement of Professor A. H. Compton, who, in *The Washington Star* of November 28, 1928, writes that ''After three years study I have proved that Einstein was correct in his theory that light-waves are made up of light particles.''

If this proof may be accepted, the same set of conditions must be postulated in any acceptable explanation of orbital motions. If light-waves of energy are transmitted by particles, inter-atomic space must contain physical corpuscles, and too many to be easily brushed aside by a large and dense planet. In such case, the earth's orbital movement cannot be explained in classical terms as though it represented unimpeded motion through a void. Nor can it be explained in terms of the Einstein hypothesis.

Dr. Luckiesh tells us that nothing in the electromagnetic theory of light ''requires a *continuous* wave-front. We may think of radial lines of disturbance. These lines may be considered to be radii of a sphere which for any wave is expanding uniformly in all directions.''[1]

This statement, also, in one sense, supports the corpuscular hypothesis. Nevertheless, one cannot conceive that an electromagnetic field might acquire mechanical reality (mechanically acting strains) solely within and by means of an imponderable etheric medium. ''Light-waves'', he says again, ''may be pictured as a series of concentric spheres with surfaces one wave length apart, expanding at an enormous velocity.'' Then he adds: ''If these radial lines of disturbance are infinite the wave-front is continuous like the surface of a sphere.''

To obtain his picture of what might be happening he finds it necessary to introduce the un-picturable idea of an infinite number of radial lines. He then thinks of such an infinity of lines as converging to a source-point. He postulates that there might be an unlimited, endless, and yet completely mechanical reality creative of limited, ceasing, mechanical relationships and results—a reality productive, that is, of phenomena which are formulable in terms of limited, and therefore, discontinuous, number-units. Rationality cannot subscribe to such a paradoxical concept. The theory has also proved unavailing. It has been denied by the facts of experience, for, as he says, Planck applied "the atomistic theory to electromagnetic energy", and, of course, the discovery that radiant energy is granular does not fit in with the concept of an infinite number of radial lines of energy. Mr. Luckiesh finally asks the question: "Will they, the physicists, ever unearth the ultimate beginning of things?" To this, one might well answer: "Not so long as they attempt to explain events in terms of pure mechanism."

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[1] M. Luckiesh: *Foundations of the Universe,* p. 128.

Mr. J. J. Thompson reached the conclusion that it was satisfactory to describe the electromagnetic mass of an electric charge as possessing a certain amount of potential energy. In the corpuscular theory, however, an energy due to moving matter,—an energy received primarily from outside any material structure in question,—is attributed to the separately moving parts of every generalized volume within the universal energy-pool, for a generalized volume is one that contains physical matter oscillating in cycles; and this energy of motion (and especially when it is abnormal) will naturally be conveyed through physical contacts to adjacent energy-volumes. In the same manner a generalized volume of water in a pond, composed as it is of molecules oscillating within a restricted range, soon shares with certain contiguous energy-volumes any unusual wave-energy that it possesses.

Unless, however, one is willing to agree that there is this diffuse corpuscular medium controlling by its energetic mass-movements the spaces between the material atoms of the elements, a fluid whose separate parts are already normally oscillating with typical mechanical energies of motion that are received from the discrete parts of the surrounding volumes, he will find it difficult to offer a rational explanation of the limited wave-fronts of light-energy. How can there be such a limitation to the side-spread of the unusual energy-waves in an imponderable continuum? What principle could limit this spreading once it starts? And how can the point-delivery of the quantum of force by the single wave-front of radiant energy be explained in terms of the classic theory? Yet, if one takes the other view, and assumes that there *is* an agitated corpuscular fluid between worlds, he will not be at the end of his problems. He cannot stop there, for his hypothesis of gravitation, and his belief in other forms of ''attraction'', will then require an overhauling.

When viewed rather grossly, as we have said, the energy of sunlight appears to expand to cover completely the surface of a sphere of which the sun is the centre. In this respect it seems to follow the principles of a restrained energy-pool composed of oscillating masses. Light-energy normally appears, too, to move in straight lines, but this, we believe, is merely an appearance. We incline to think that the motion is straight because we usually interpret the course of the light-beam grossly as to time and space. If light-energy could be observed in detail it would doubtless be found to take a zigzag course. No energy-wave can travel far through the inter-atomic spaces (through energy-volumes, that is, which are themselves composed of separately oscillating parts conveying energy) without innumerable deflections.

A water-wave, too, appears to move in straight lines through generalized space and time, but the separate molecules transmitting the wave-energy follow courses that are separately haphazard. Only the averaged or generalized interpretation of the path of a wave, whether of light or water, indicates a consistently straightforward course at some typical speed, and this is an erroneous interpretation of reality. Yet, since the transmission of light-energy, even to the gross view, displays a perceptible sidewise spreading of the unusual energy as then proceeding through a certain volume, the gross interpretation is proved to be erroneous, and the unperceived zigzag course of the imperceptible particles conveying the energy is thus virtually proved. Does not reason inform us that there could be no such side-spread of the energy of granular particles except that they took such a haphazard course through short distances? Nor could the energy be granular unless it was delivered by granules.

Now if a wave of the ocean passes through a narrow canal into a bay, the unusual energy creative of the wave will develop a perceptible side-spreading at the junction of the canal and the bay, but, even so, it will not diverge sufficiently to reach the shore of the bay just around the corner. And as to the shore line which it does reach, it will deliver energy only to those discrete areas of the whole which contain matter and which the water-molecules happen to strike. The effective or energy-delivering wave-front, is not continuous, and the velocity and angle of its side-spread are both limited. The same general principles apply to light-waves.

Light-energy behaves much as does water-energy. Moreover, in the proportion that light-energy, as localized in a few rays, becomes more intense (that is, more concentrated), the faster it spreads into those adjacent energy-volumes which are normal in their energy-expressions. Indeed, if light beams are sufficiently dense—as when many rays are condensed by converging reflectors—they appear to the gross view to be repelling one another at a distance. No power can make them condense more than a certain amount, and any unusual influence tending to condensation quickly ends. None of this, however, exemplifies repulsion at a distance. When the rays appear to bend away from one another their motions are resisted less in the directions of those volumes alongside in which less energy is being expressed. This has the final result that unequal energies are not for long (in the average) expressed in contiguous volumes. Thus the unusual energy-volumes, as represented in the wave-controlled spaces of light-rays generated on this earth, will not condense indefinitely, as experience proves; nor will two such rays for long move in close parallel lines through space that is exhibiting normal energy. They will separate, but the separation is due, not to force acting at a distance, but to the zigzag motions of the separate tiny parts composing the wave-fronts as they haphazardly deflect from one another. These phenomena subscribe to the corpuscular theory, and they are different from what might be expected if light-waves were undulations in an ether-continuum. Let us now see if we can obtain from this hypothesis an inkling of the reason for the invariant quanta of energy displayed by electrons radiating from atomic structures. First, however, it might be well to refer to a modern concept subscribing to our view that matter is being annihilated. This very modern opinion, although it is not carried on to the conclusion that we call for, in one sense supports the view that gravitation is due to the transmutation, within a balanced energy-pool, of the ponderable material arrangement into the imponderable spiritual essence.

In *The Universe Around Us,* Sir James Jeans writes that: "On the whole, in whatever direction we try to escape from the hypothesis of annihilation of matter, the alternative hypothesis we set up to explain the facts seems to lead us back in time to the annihilation of matter." (p. 178) And again he says: "And the amount of this radiation [the highly penetrating radiations received from inter-world spaces] received on earth is so great that we had to suppose the underlying annihilation of matter to be one of the fundamental processes of the universe; we now discover that it is in all probability the process which keeps the sun and stars shining and the universe alive." (p. 181)

But what, let us ask, is the Power creative of the annihilation of matter? Surely it is not a spontaneous process! On another page Sir James writes: "Modern physics is only able to suggest one process capable of providing a sufficiently long life for a radiating star; it is the actual annihilation of matter."

Here the modern scientist seems to have reached a view indicating that matter-properties are not primary, for matter itself can be annihilated. Nor is the mechanism of matter monistic, for the process ending in its annihilation must have an extraneous cause. The modern thinkers, however, do not accept these implications. They seem willing to believe that the process *is spontaneous,* and suppose that, by it, the matter-property may be transmuted, not into an immaterial essence, but into a free energy that is still mechanically grounded because it obeys mechanical axioms and formulas. The energy is assumed to be of the ordinary type except that it does not make use of the inertia of matter for its force-expression. They do not seem to think it necessary to explain the nature of this inertia-less energy, nor do they attempt to give a reason for the spontaneous change of the energy of moving matter into an equivalent mechanical energy that does not make use of the matter-property.

We, however, do not conceive that the spontaneous annihilation of matter is real. Nor do we believe that the annihilation of the matter-property, however caused, can possibly release free energy that might still be regarded as conventionally mechanical, or that would follow mechanical laws, or that might exist independently of the property of inertia that is possessed (so far as we can tell) solely by matter. We do not believe that a "spontaneous" activity permits the stars to send out "free" radiant energy possessing mechanical potentialities. On the contrary, we are convinced that these radiant energies are real to us mechanically (and are, therefore, exceedingly powerful factors in many mechanical relationships) solely because they do involve (and in a large way) the inertias of moving physical objects.

According to our view, also, the Evolution of matter involves the annihilation of the material property—or arrangement. Thus far we subscribe to the concept of Sir James Jeans. We believe, however, that a destruction of the material inertia-property within a certain energy-volume (to be regarded as a volume controlled energetically by the moving energy of the inertia of this very piece of matter) will leave within this volume, not free energy unattached to matter, but a mechanical void—the negative, indeed, of the positive energy-reality that he appears to postulate. This mechanical void is analogous to the vacuum of the vacuum cleaner. It has significant energy-potentialities, but only because it is an *unusual* energy-void within an energy-pool, and one that thus constitutes an unusually unbalanced mechanical relationship with the other energy-volumes of the universal pool. The positive act is the creation of the abnormal energy-void by the annihilation of matter. Then, because there is this association between the void and the positively moved matter that remains, the *unusual* energy-void becomes mechanically significant—but its significance is negatively grounded. The unusual void lacks that amount of mechanical energy which in the average it *must* possess. Mechanical adjustments then follow; and these lead to unbalanced mass-motions expressing mechanical energy of the usual type.

These adjustments following every Evolution (annihilation) of the material property of inertia, however, do not account positively for radiant energy, but they do account positively for those unusual energy-expressions known generally as "attractions." They account for the gravitational movement-tendencies between the denser structures. And (but again in a negative sense) these adjustments account for the radiant energies that emanate from the denser masses into the spaces between the atoms, because gravitation itself (and the orbital motion flowing from it) is due to the adjustments of the relationships of the denser masses which follow the unusual annihilations of matter within the denser structures (the atoms). Radiant energy emanates then from the denser atomic structures into the inter-atomic and inter-world spaces. This comes about because further mechanical adjustment is necessary to bring about the final average of energy-equilibrium throughout the volume of the larger energy-pool.

According to our hypothesis, this generalized uniformity of energy-expression is purposefully maintained. The Cause of motion in general sees to it that the loss of the usual energy within certain volumes as occasioned by the annihilation of inertia, will be quickly adjusted by the compensatory movements of other inert bodies. We must realize, however, that the amount of spiritual energy in the universe does not necessarily decrease as the quantity of matter decreases. On the contrary, the spiritual energy, the moving power, is probably increasing. At least we may suppose that it will increase in relation to the smaller quantity of matter that remains. The motion of the average matter-particle should therefore become more intense as Evolution proceeds; and new adjustments of the average energy-expressions should become necessary as evolutionary changes take place. Hence, the more complex atomic structures will tend to disintegrate. For this reason, also, the atoms of the dense structures of stars and sun steadily display outward unbalanced energy-movements of invisible and imperceptible corpuscles —radiations which we sometimes erroneously describe as ''spontaneous'', and which we sometimes incorrectly think of as being transmitted by means of an imponderable medium through an inter-world void.

Sir James Jeans estimates that each second the sun is losing four million tons of mass (and weight) by the annihilation of matter. This, by its spontaneous transformation, is supposed to account for that free energy which emanates from the sun as heat, light, and so on. He believes, apparently, that these energy-radiations are directly due, in some fashion which he does not attempt to explain, to the annihilation of matter as such. He appears to think that when matter is annihilated its material reality is automatically transmuted into mechanical energy which is conventional except that it has no relationship with inertia or the physical. Moreover, it then has nothing to do as an energy-reality but radiate with unbalanced energy-effects in that imponderable medium which conveniently happens to be present to fill the spaces between the atomic parts. All this is inconceivable. And it is equally inconceivable that the energies of motion now displayed by the discrete parts of the atoms of the elements should ever be released by a mechanical process so that—as some scientists now predict—they could be utilized as sources of original power to drive the machinery of the industrial world.

Let us now see if the theory of physical Evolution (which we believe has given a fair account of itself thus far), will further demonstrate its reasonableness by giving an understandable explanation of the fact that the energy of radiating electrons is always expressed in multiples of what normally appears to be an invariant quantum-quantity. We have already learned why the faintest of blue lights (as that coming from the star Sirius) can eject an electron from an atom of the earth with greater velocity than will follow the impounding of far more intense red light.

In developing the corpuscular theory of gravitation in chapter XXVI, we described the unit of the gravitational influence (the negative) and called it F. We believe that both the unbalanced gravitational tendencies and the unbalanced radiant energies are derived from the annihilation of matter, and that both, therefore, are expressed in multiples of that unbalanced energy which appears when the inertia of one corpuscle is destroyed by Evolution. According to this hypothesis, both gravitational and radiant energies are granular, and both are expressed in multiples of an energy-quantity which for all practical purposes is invariant. The gravitational force-unit and the quantum-unit of interatomic radiant energy (h) are closely related. Indeed it is possible that they are the same. At least they both derive from the same Cause—from the phenomenon of Evolution as the primary source of the mechanical necessity that there should be this readjustment into a new average of mechanical order. Since, however, radiant energy is expressed through the positive motions of matter-particles in a physical fluid, it is always expressed in granules—that is, it is delivered by one corpuscle at a time and in one direction at a time. It is both a point and a uni-directional delivery of energy. It is therefore amenable to mathematical enumeration in terms of number-units. When, however, the unusual energy, as thus aroused in a certain volume, has once been transmitted, has once been expressed in one direction to a piece of matter alongside, it cannot again be expressed by this same energy-volume. On this account, one unusual energy-expression of a particular sensation-type can be expressed against only one object of all those in the contiguous energy-volumes. Therefore, as Professor Eddington suggests, the delivery of this amount of unbalanced energy to any one of these objects of all the other adjacent energy-volumes in this general direction, is, to some extent, a matter of chance. If ten objects have approximately an equal chance of receiving the entire amount of unbalanced energy, and if one only of the ten will receive all of it, then each of the ten volumes has a one-tenth chance of receiving it. The principle is similar to that illustrated in the chapter of Gravitation and need not be repeated.

The corpuscular theory of gravity gives us, therefore, a fairly clear conception of the quantum-phenomenon. We do not need to go into it further, or try to develop its implications in detail. The quantum of radiant energy should leave its source as approximately an invariant quantity, but the amount of unbalanced energy delivered to another object should depend also upon the factors as described in the illustration of the two boats. We shall not discuss these details further. Nor shall we attempt to explain why every element at a certain temperature gives off a certain colour; nor why electrons will not be knocked out of an atomic structure by light-rays (for a time, at least) unless, as the physicists have proved, the waves have a length that is at least no greater than 860 times the diameter of the electrical structure of which the electron is a part. These results should follow directly from the hypothesis of causes and conditions as here set forth.

The true quantum of energy, then, is that amount of unbalanced energy which is manifested within the universal energy-pool, and in respect of the universal centre of mass, when one of the corpuscles is annihilated. The effect of this unbalancing pervades (in time) the mechanical pool. No other type of mechanically grounded unbalanced energy is so "absolute" (in the sense of standing for significant change in universal physical relationships—and in the relationships, also, of universal mind with matter) that its mechanical influence can, in the average, spread until it reaches the restrained borders of matter as a whole. The sum of the quanta of energy manifested during one second within the entire universe in one sense measures the total evolutionary accomplishment during that interval.

This discussion must now be brought to an end. None of the phenomena of light,[1] none of those proved facts which when otherwise interpreted seems to lead to the Relativity-concept, seems to conflict with the corpuscular hypothesis; and, whereas the Relativity assumption that Time itself can be changed by relative motion so as to influence mechanical events, does conflict with the theory of causes here outlined, there are reasons for denying the view-point of the Relativists. And although the analysis has been far from complete, although it is nothing more than a generalized sketch, it seems to have dissolved some of the paradoxes of modern physics. On this account my confidence in it has been strengthened. The corpuscular hypothesis, based as it is on the postulate that there is a planned Evolution of material corpuscles, appears to lead towards a blending into a consistent whole of thought-shapes which when placed in other theory-structures have seemed irreconcilable.

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[1] Several well known light-phenomena, which cannot be understood in terms of the ether-wave theory, are more amenable to explanation in terms of the corpuscular theory. Among them are the following: (1) A rapidly revolving disc, painted in sections alternately black and white displays, red and green colours, where the sections meet: (2) At night red light has a range of three to three and one-half miles whereas purple light has a range of less than one mile. Yellow green gives the maximum light sensation: (3) A very hot flame is bluishly invisible: (4) Dim blue light appears bright when dim red light and all illuminations are dim: (5) An object coloured in a white light may be black in a red light: (6) Colours decay.

Then, too, the proof that the abstractions of Space and Time—so far at least as they refer to the voids between inertia-volumes—do not participate in the unit-reality that composes all gross mechanical events, seems particularly sound. Yet, if this proof is valid, there remains no place for a hypothesis like Relativity. And as to those who are unable to accept the inconceivabilities of variable Time and curved Space-Time, they will be forced to admit that in some (and perhaps in almost all) of the mechanical relationships, the doctrine of Conservation has proved unsound. When, however, this admission has been made, it will be realized that science can be made self-consistent only if there is introduced into its fundamental formulas and principles the influence of a spiritual Cause, or that real and absolute Power, indeed, which even maintains the field of mechanics.

It has seemed to me that until recently science has been based too firmly upon rigid opinions which themselves have been founded upon grossly averaged and therefore limited experiences. Science has erroneously accepted (as if exactly true of all fields—its great mistake) the uncompromising axioms which derive from those certain large aspects of that part of the physical which can be sensed (but sensed with only approximate accuracy—even as generalizations), and which, therefore, have disclosed what appeared to be orderly routines amid what are really separately chaotic happenings.

Routines, moreover, have been found to be subject to mathematical formulation, because, in this generalized fashion, they may be expected to repeat themselves with some measure of consistency, and because, indeed, only these orderly routines have been sensed. The philosophic viewpoint, moreover, has almost been ignored by the classical physicists; and the philosophers, in turn, have mistakenly accepted the findings of science as if exactly valid. And as to the modern point of view, it has not yet reached a conclusion. Its present assumptions, lying as they do in the field of the metaphysical, appear to be attempts to adhere to pure mechanism in realms of diffuse physical experiences where the phenomena are least apt to be orderly, where the unit-phenomenon is most apt to be recognizable, and where, really, the decisive influence of a great spiritual Cause more clearly demonstrates its power over mechanics. And to-day some of the leaders of modern opinion even incline to think that no firm knowledge will ever be attained.

We have surrendered almost all the axioms of the old physics. We have concluded that if our knowledge of the physical relationships is to prove sound it must subscribe to the principles of a pulsating and ever-changing whole—to the kind of Change in the whole that no theory based on pure mechanicism can ever indicate, and no mathematical formula ever measure. According to our view, no part of the material whole is isolated, or out of relationship with other energy-volumes expressing in the average an equal amount of mechanical energy of impact. It appears to us that in the average each energy-volume is what it is, and expresses itself as it does, partly because it is affecting the near-by corpuscles,—pieces of matter which by their movements, in turn, are controlling the energy-volumes exterior to them,—and partly, also, because these external corpuscles are affecting it. Working formulas, we contend, must correspond with these facts of dual relationships and inter-relationships—conditions which are gradually changing even in the average. Hence a large part of the reality of every material structure with which we treat (and concerning which we desire knowledge), is a product, not of the structure itself when regarded as a self-contained whole, but of its energy-environment. For this reason no theory can be sound if it conflicts with, or fails to account for, the phenomena of the relationships of the mechanically-controlled energy-volumes one with another. Knowledge must therefore embrace and account for the principle of Change in *universal* mechanical relationships, and must, therefore, reach realms beyond the direct perceptions.

And as to the Relativity-hypothesis, because, as we say, knowledge of an object must be consistent with all of its internal and external relationships, one feels justified in denying that Time might anywhere affect average energy-delivery. We claim this with assurance because we are convinced that Time does not participate in *unit* energy-delivery—that which normally we cannot sense but can reason about. If this is so, Relativity cannot be valid of the smallest event. Nor can it then be a true principle as referred to the broader fields. If, moreover, a purposefully created Evolution is the source of the change in the averages, and of the unbalanced quantum-effects that are thereby displayed in the inter-atomic relationships, we require no other explanation of the unbalanced energy-expressions which we are able to "sense" than that which an acceptance of the reality of the mental power behind Evolution might afford.

When the mind understands its own nature and its own powers, it should have complete knowledge of the phenomena of the universe both statistically and philosophically. The attainment of the truth of the relation of mind with matter will solve the problems of the three principle fields of thought—science, philosophy, and religion—for they, after all, are branches from one stem.

These different subjects, all so interesting to human minds, to-day seem to have developed contradictory principles. They appear to be almost irreconcilable. And yet, almost everyone feels that, notwithstanding the apparent oppositions of the moment, they will eventually be discovered as harmonious aspects of a greater unity. This can come about only when the absolutely true concept has been attained—one which is the logical conclusion drawn from an absolutely correct premise. This true premise will surely be found to fit perfectly into, and to subscribe perfectly with, the separate principles as determined by experience, reason, intuition, and art. Such a premise, indeed, will be the true statement of that Principle and Power which creates the mental and mechanical happenings of life. It will identify for us the unit Cause of those events, mechanical or emotional, which we attempt to classify separately as philosophy, religion, and science.

CHAPTER XXXI

AN IMAGINARY CONVERSATION

> The universe is but a radiation of mind; and the radiations of the Divine Mind are for us more than appearances; they have a reality parallel to our own.
>
> AMIEL.

AN IMAGINARY CONVERSATION BETWEEN THE PUBLISHER AND THE AUTHOR

Scene. The Publisher's Office.

THE scene is not restful. Efficient people rush about, telephones jangle, call-bells buzz. It is the tense atmosphere of business. Efficiency lurks even in the corners. The vacuum-cleaner has sucked out the last particle of dust that might have eddied in the sunbeam. The books spread for the inspection of the visitors are crisp, clean, neatly bound for economy and durability, and their bright jackets attract the jaded eye.

The Author follows a messenger through a passage winding among the desks, telephones, and noise, and is ushered into the dignified room of the Publisher. Here the door is closed and the noise fades.

The usual sheet of plate glass glares from the desk; but one need not look at it for the harbour of New York glows beyond the leaded windows. It is lovely outside. The sky is filled with billowy clouds and sunshine; and a huge steamer just unleashed from her tugs is beginning her journey eastward. Some three blocks long she ploughs an irresistible course through a sea, which, in other moods, seems unconquerable. Even the Publisher, accustomed to the scene, seems to feel an emotion, and he and the Author begin to talk on subjects foreign to business.

A. Isn't she magnificent—that Colossus? How enormous she is! The largest waves cannot disturb her. In her, man conquers Nature!

P. Only when the winds are still. In the heaviest seas she tosses like a toy-boat. The waves may even crush her sides. When Nature is unusually aroused her forces make the mightiest works of man seem trivial.

A. Yet man does show here a measure of control of mechanical forces. Indeed, the sight of this powerful steamer makes me think of a fascinating subject—the control of matter by mind. Everywhere I turn I seem to find examples of mechanical power directed by mental power.

P. You have discussed this subject at length in your book; I have learned that it is a combination of physics and philosophy.

A. Physics and philosophy—that is to say, matter, mind, and their relations. Yes, the book does deal with these. It wanders.

P. Why is that?

A. I like to combine ideas, and to relate phenomena to one another. I am a generalizer. I suppose I am a visionary.

P. This book doesn't seem as practical as your other. It is more in the air.

A. In one sense, yes; but in another, no. I have attempted to identify the basis of phenomena. I have hoped to prove that there is a Cause which day by day is carrying out a plan. I have tried to prove the presence of a God whom any reasonable man might worship. I have attempted to prove this philosophically; and then I have attempted to demonstrate that the activities of this Presence reign supreme in the heart of mechanics. What could be more practical than that?

P. Have you succeeded?

A. Others must pass upon my proof. At least I have helped myself, for I now have new assurances. The usual present-day viewpoint, moreover, it seems to me, is inconsistent, absurdly so; almost anything is better than what we have.

P. What do you mean?

A. During the week our children are taught that no divine power influences their lives. Then, on Sunday, they learn to worship a Father above who directs their happiness, and who guides their steps lest they stumble. Is this consistent?

P. But surely the schools do not teach that religion is untrue!

A. Not directly, but they do indirectly—although I admit that most children do not realize the fact.

P. I don't understand you exactly.

A. Mathematics, physics, mechanics, thermodynamics (sciences of the schools which child and parent accept literally), are at odds with the precepts of religion for they are built on the postulates that physical action and reaction are equal, and that there is not, never has been in their lives, and never can be, an exterior influence which might alter even for a moment the perfect validity of these coldly systematic mechanical principles. Mechanical Conservation, not spirituality, is the touchstone of the school. In mechanics, as now understood, there is no place for divine intervention. And yet what God is worthy of our worship Who cannot intervene, Who cannot express His will with life, Who is unable to alter the physically ordained course of the tiniest particle of dust, Who is a mere onlooker, a negligible observer, Who may be there as Faith proclaims, but Who, so far as He changes our fate, might as well be absent? Is it not foolishness, this prayer for rain, for does not the falling of rain depend upon a chain of physical events which are quite beyond the reach of this alleged powerless God? What reasonableness is there in prayer, even for its effect on the mind of him who prays, if there is never a response, and if the person is himself a type of mechanism submitting solely to physical influences? No, if mechanics and physics were as supreme as some claim, religion would be ridiculous, the efficacy of all prayer chimerical, and faith a mere emotional contortion.

P. You assert, then, that so long as man accepts implicitly the mechanically founded sciences there is no place remaining to him for religion or faith. If this be true, I must admit that either Reasonableness as scientifically defined must be divorced from the religious life—quite an irrational procedure for the most rational of animals—or else Reasonableness as mentally defined must prove mechanics irrational.

A. Yes, that is just it; and in my book I have attempted both emotionally and logically to show that the Conservation doctrine, which is the principal foundation of physics, is irrational. In this way, I have, I believe, left a place for a reasonable and true religion to enter our minds and hearts—a religion that even the most scientific person who accepts my argument might accept as rational.

Why should this venerated mathematics, for example, be supremely applicable to our world? The beginnings of mathematics, as I have pointed out, were founded on certain types of experiences with physical bodies, and not on Reason. And then, later, mathematics was developed abstractly—that is to say—in realms separated far from the facts of the physical world with which it stated. When this mathematics of the empyrean was brought down to earth, and hitched to clumsy experimental physics as a running-mate, a strange team was formed. Physics is a remarkable combination. It is a science of generalized and orderly experience—that is, of a certain type of experience inexact though it may be—attached to a science compounded almost entirely of physical unreality. Physics is supposed to be justified more through experience than logic. Experience has been the final test of its validity. Mathematics, however,—and particularly modern mathematics,—has been developed in part separately, and, after being set up abstractly, its laws have been applied to interpret these generalized mechanical situations. The answers in most cases have been tested after a fashion by other generalized experience; but, unfortunately, the exact test has been impossible. Nevertheless, the abstractly derived mathematics has usually prevailed as if final truth. Even the calculus is in reality a generality harmonizing only with the generalizations of a certain type of orderly and experimental mechanics. The mathematics was reached artificially, by the expedient of dropping certain small quantities, thus leaving a blurred picture. After doing this, it has been believed that the formulas would exactly translate reality—and that dynamic reality might be a continuum. At least this has been believed in every case where the minute test could not be made. Often when the generalized experience has contradicted theory, the theory has been abandoned. Broad summarizations of experience have normally been accepted as if indisputably valid, and the mathematics has been fabricated so as to conform to this conviction and method.

We may say broadly that in higher mathematics reason has abandoned the discontinuous physical facts, treating with them unreally as if generalities and continuities. In physics, the generalized appearances of things have prevailed over contradictory conclusions appealing to reason alone. Then these sciences, developed partly on experience contrary to reason, and partly on abstract reason contrary to the physical realities, have been used to interpret our world and our lives. Yes, we must forget these scientific formulations as we enter the door of the church. Or, at least, they must be regarded as only partly true—as nothing more than practical working rules—if one would believe the religious teachings.

P. You are convinced, evidently, that science is largely based on error, and that religion intimates the higher truth.

A. The sciences are evidently no criterions for the theorist. This is admitted by the broad-minded scientists. As Professor Eddington says "Exact science invokes, or has seemed to invoke, a type of law inevitable and soulless against which the human spirit rebels." In some cases the formulas of science give entirely incorrect answers; and in all cases they are partly incorrect. The laws of physics have proved less trustworthy than scientists have hitherto been willing to concede. The theories of the reversed motions and energies of particles within the whole, for example, develop a paradox which cannot be solved until one assumes the presence of a universal and accomplishing Cause. Only if placed on a religious foundation —a foundation of purposed change, a foundation which includes Evolution as the accomplishment of the motions of the absolutely restraining force—can science be made consistent. And then it becomes not only completely consistent but completely religious as well. The purposeful Cause then appears as a real Creator of destiny, as a real Maker of life.

P. Do you go so far in your belief in this intervention of a mental Cause as to suppose that prayer for rain, for example, might influence Him to alter the weather—that He would or could grant such a prayer?

A. I do not believe He would now heed this prayer; but I do believe that the mental principle will some day exist in man so potently as to permit him to temper the fall of rain to the extent at least of determining whether the rain shall fall to-day or to-morrow. I do not believe, however, that the Cause on high suffers the routine of his world-processes to be altered as a whole, or for long, for the sake of insignificant humanity. I rather agree with Rousseau and Thomas Paine that much of our prayer is mere impudence; nevertheless it is perhaps to be excused because of our ignorance and lack of appreciation of our own place in the scheme of things. Yet, as William James said, prayer of the right sort has its beneficial influence on the person in the religious mood. Communion with God is uplifting. This outlet of emotion, this expression of faith, this effort of belief, seems to permit some of the unconscious to become conscious in man; and thus he is elevated.

The writing of an exquisite poem, also, or the composing of an inspirational musical theme, may prove beneficial. The conscious liberation of the intuitive mood seems capable of withdrawing the thought from the hidden instinctive regions of our minds, and of fixing it as a new attribute of consciousness where we can thereafter make use of it. M. Gustave Geley believed that our development as mental beings was nothing but a transition of the unconscious into conscious mentality. And so did Leibnitz before him.

P. Where do you place men in the evolutionary scheme? Is his presence important? Is his progress assured?

A. All Evolution is important, and each example of it represents accomplishment. Man is important as a living and evolving being. In him the mental appearing is exceptional, and it lingers in him sufficiently to direct his life. His mind is somewhat conscious of his body and its problems. Man is more Godlike in his mental expressiveness than the other animals of this earth. Yet, so long as he is so weak mentally, so much a physique and so little a creator of his own destiny, I cannot attribute any particular significance to him. That is to say, I do not think his presence would be sorely missed from the universe.

The astronomers believe that no organism like ours, breathing air and composed largely of water, exists elsewhere within the solar system with its approximate thousand of separate worlds, large and small, unless, perhaps, on Mars and Venus. The larger bodies are too cold, and the smaller ones are either too hot or have insufficient oxygen in the atmosphere. Only because certain chemical elements are now present (doubtless temporarily) are we enabled to have our air and water, and bones and flesh and tissue. Without carbon—the atoms of which possess the remarkable quality of uniting in long chains—the enormously complex molecules of organic chemistry, and our life as we know it, would be impossible.

We are also in extraordinarily delicate balance with the physical environment. Our life hangs by what in some views seems to be a most delicate thread. With the least change of strain it will snap. Thus the temperature of our blood is about 560 degrees above absolute zero, and a two per cent. variation in it will destroy us.

Organic bodies are distinguished, too, by the associations of colloids with carbon in solutions wherein the molecules have enormous surfaces in comparison with the crystalloid formations of the inorganic world. These large groupings permit our bodies to have their distinguishing characteristics. With the disappearances of carbon and silicon—elements which some day will doubtless disappear—these organic formations of to-day will no longer be known.

P. Then, as I understand it, if our earth were as far from the sun as Saturn or Jupiter it would be frozen; if as close as Mercury it would be boiling hot; and if too small it could have no gaseous atmosphere. Earthly conditions are exceptional. They represent a fortunate combination which alone makes our type of organic life possible. And, as you suggest, these conditions are not permanent, hence life like ours cannot be permanent. Nothing very important, therefore, can be represented by the type that happens to inhabit this particular little grain of dust which is our earth.

A. That is a fair summarization.

P. Are you pessimistic, then, about the future of the human species?

A. Not pessimistic, for there are too many possibilities beyond human understanding. We cannot prophesy—we do not know enough. I believe, moreover, that Evolution will proceed whether or not any conscious species continues to exist. The important principle of Becoming is revealed in the transformation of matter into spirit. This is the large accomplishment, the significant Change; and it will proceed whether or not life-forms exist to be conscious of it. It is our glory that mind-power appears in us, is created out of us. It is not so important that this mind lingers sufficiently within us to be conscious of our bodies. The desired immortality should not refer to the body, but to the soul, not to the mind concerned with our insignificant earth-problems, but to the mind freed from its physical personality. Pure mind-power is doubtless imperishable, but what we call our personality is not important, for it is mostly physical and impermanent. It is more temporary than the colour-shapes in a soap-bubble.

The mind carries its own personality with it. The physical part of our personality, that which we are inclined to cherish, is less important to the spiritual in us than the paint and false hair which the actor uses for a moment to represent a character on the stage. At death, the mental part merely changes the make-up so as to assume a new part and personality. In the excitement of the new part of Romeo the old Shylock may be entirely forgot, but shall we mourn the forgetfulness?

Death is no hardship. We should complain rather about life. If we are to be subject to the possibilities of fears and pains, we are entitled to more mental freedom, to more conscious power to direct our own fates consciously while here on this earth in the midst of destructive physical pressures. We should be more alert mentally, more able to escape that which causes fear and pain. Life to-day is too cruel.

P. I agree with you there.

A. The most painful stage of a transition now afflicts us. The pain of life is sure to diminish—whether human mentality achieves a complete understanding, or whether it disappears into the sodden deadness of tree or stone. I believe that our mental capacity will steadily increase; but in any event we are inclined to make too much of a transitory state. The temporary is not very important when measured against the eternal, and we can readily excuse the suffering of the moment if it is finally to be justified by a higher and enduring good. It is probable that before men have explained the presence of evil in harmony with their religious creeds the pain which torments them will have disappeared. The boy learning to ride a bicycle, or beginning to skate, minds the bumps and bruises less because he realizes consciously the reality of what he is doing in acquiring a new talent. He realizes that these are not lasting afflictions, but merely incidents necessary to the acquisition of an advantageous art. He consciously realizes his steady progress toward skill. He understands that he will be painfully awkward only during the transition stage, and that the compensations and comforts of the accomplishment will much more than repay him for the temporary hardships. Likewise, as soon as our minds can understand the reality of that we know as evil, and can appreciate why it is temporarily necessary during the passage from lower to higher, we shall not mind it so much. We shall be buoyed up by our pleasing expectations. We shall realize that pain will not last; that it is present only at intervals even now; that pleasure and satisfaction are positive factors in life, not the mere negatives of evil; that the evil which now exists is unessential, and that to-day it is merely an expression of our awkward age; that we shall grow out of this awkwardness; and that, eventually, our minds will be sufficiently strong to dispense altogether with these bumps and bruises. Some day we shall glide peacefully and serenely, and the anticipation of this day of mental attainment should give us some happiness now. Happy mental expectations can themselves balance a lot of present suffering.

P. I quite agree with you. A justified creed of optimism for the future will do much to help us over the present. But am I to understand that you believe that every plant and stone partake of evolutionary change, and that the spiritual, or mental, appears in them as in man?

A. I cannot believe otherwise. The differences in the species of the earth seem to be brought about by variations in mental understanding. One species appreciates more completely than another the problems of its own body, and is more consciously aware of the relations of its own organism with the physical environment. Now this conscious understanding of self seems to depend primarily upon the length of time the mental power stays within the body in which it is created. As the mental power is more enmeshed in the physical structure, as this structure becomes more complicated, as the surface-irregularities of its parts increase, these structural parts seem to interfere the more with the escape of the mental steam, as it were, and the mind lingers for a longer time in the physical organism and more expresses its power over that body. Only because organic bodies contain sufficient mental power to direct themselves in their physical earth-routine are they to be distinguished from stones. We note the differences in mental appreciations, and we refer to some organisms as being alive and to others as dead. More than likely the distinction is one of degree only.

Mental force is doubtless created in the stone; but it apparently escapes freely between the minute crystalloids of the inorganic body. Because there is this almost free passage—so different from the escape from the formations of bodies said to be alive—the mental power escapes from the stone without organizing or motivating it appreciably. The stone has no recognizable free-will, nor life-cycle, nor process of reproduction. There is no appreciable reconstruction of bodily losses through a mental agency within. It is not alive in the sense, or at least to the degree, that would cause us to classify it as alive. Nevertheless, a mental force appears in and escapes from it. Indeed, Sir J. C. Bose, of Calcutta, seems to have demonstrated with his remarkably delicate instruments that trees are alive in the sense that they have heartbeats, can be influenced by drugs like human beings, and can be killed by poisons. Metals also "respond to stimuli, are subject to fatigue and react to poisons very much as living vegetables and animal organisms do. . . . Everything, including the 'inanimate', is alive."[1] The stone participates in evolutionary change, but the mental power remains in it so transiently that it usually escapes detection. From day to day the mental power in a stone does not influence it importantly.

P. To refer to an analogy of yours, in the inorganic structures the steam of life finds an open valve which permits it to escape unrestrictedly to the sky without doing work, whereas in the living organism this spiritual vapour is surrounded by packings and tight joints, so that it must operate the physical mechanism before it can depart. Through mechanical operation it finds its easiest path to freedom.

A. Yes, that is my concept of it.

P. You believe, then, that the same *quality* of mental power issues to immortality from both man and stone?

A. This is a most difficult question. It is all hypothesis. I am merely guessing in the way that seems reasonable. I do believe, however, that the mental power issuing from the stone is no different in essence from that coming from the physique of a man, but the two relationships of the mind with the organisms are decidedly different in degree, and this gives important differences in result.

P. If life, as you say, is the result of mind-power acting with reference to a physical body, why does life ever cease? Why shouldn't vital force be created within the organism after that which we call death has conquered? And why, also, does not the person follow his mind-power from one personality to another, and associate them?

[1] Aldous Huxley: *Jesting Pilate,* p. 178.

A. As to the first question, I see no reason why mental power should not be created in the dead body of a person just as in a stone. Yet the organism of the human physique, with its connections of complicated and interdependent parts, is destroyed when that which we recognize as death occurs. A body is not organized entirely through its physical-chemical properties; but a mental power arranges and operates its parts. A vital force is necessary for its unit-response, for its repair, co-ordination, and maintenance. The organism dies when such a wide break exists between its parts that the unit-control cannot be maintained. Similarly, when a wire breaks in an electric motor, or when the current of electricity has become unduly weak, the mechanism will cease to operate as a whole. There is no longer a co-ordinated unity. I must believe, nevertheless, that the evolution of matter into spirit should proceed within the body whether it be dead or alive, whether organized into a homogeneous unity or whether disintegrated into separate parts.

P. This may be true.

A. You ask also why, if the mind escapes from the body, it does not carry its personality whither it goes. As I have already suggested, the mind carries along with it that which we may call its mental personality. Why then, you ask, does this mind-power not associate its different personalities? Why does it not remember the old part while playing the new?

By personality we usually mean the physical part of memory. The mind plays over the record of a body grooved with physical events, but this memory dies immediately when the mind leaves the body. For one moment the mind is conscious of a certain physical make-up, with certain relationships of parts, with certain grooves of inscribed events, but surely, as soon as this association is at an end, the memory, as thus understood, will vanish, and the physical personality will no longer exist. In its new environment the mind will have a new *person,* and a new set of physical memory-grooves. I have written a number of pages about this.

The physical personality which we cherish and wish to retain is but a temporary association. It alters even as old age creeps over us with its bodily changes. This consciousness of the person is not fixed; it is not permanently one sensation. Hence, surely, the mind-power which from moment to moment passes out of us does not carry with it any recollection of any particular stage of that changing association.

I have heard people say that immortality meant nothing to them unless they could carry into the next world memories of earthly friends and experiences. It is natural that they should feel this way, for not only is this earthly existence their only realized reality, but it is also principally a series of physical impressions. Yet, when the mind has been released from this earth-environment, it will, I dare say, have no regrets. How can it regret what it does not remember? It would not care then to cultivate old memories, and will not lament that the former types of physical relationships are absent.

P. That is fairly clear. As you say, our clinging to our earthly personality, and our desire to carry it away with us to another world, is natural, but this does not make it reasonable to a larger view. But what about the life-cycle of youth, growth, and old age? Have you any explanation of it?

A. Let me try first to answer your other question. You asked me about progress—whether I believed that the genus man would evolve into a constantly higher type of being.

Now I cannot doubt that the birth-processes will produce a more and more potent mental type. It is foolish to attempt to prophesy how far this mental development will attain; but I do believe that man will acquire sufficient mental understanding to improve his life greatly. The evils and injustices of life which now arouse such bitter criticisms will doubtless be eliminated soon by a more perfect mental control. Yet Dean Inge, Lord Balfour, Bertrand Russell, and many others, deny all progress during the past many thousand years, and expect no improvement in the future. They deny that man is participating in a process leading inevitably to mental advance, and they believe it likely that our lives will be extinguished by collision with a passing star, or by some lower order of microbic life. Any slight change in earth-conditions, they claim, will eliminate the human species with all its achievements and hopes.

In a recent book Dean Inge writes that "Consciously or unconsciously the champions of the historical method are often the victims of the great superstition of the last century, the belief in a natural law of progress."[1] He goes on to say that there has been very little, perhaps no, intrinsic progress for twenty thousand years. He remarks that "Our brains may follow our teeth, claws, and fur." "What we call progress is a biological episode which other species, such as bees and ants traversed long ago." These bees and ants finally reached an *impasse*. After the establishment of a stable civilization they ceased progressing. And, "It is more likely than not," says the Dean, "that our species will come to rest in the same way, unless our present habits end in mutual extermination."

P. What do you think of this somewhat dismal prophecy?

A. I am not particularly concerned about the distant future. I believe, as I say, that man will develop into such a high type of mental being that he can largely control his environment. He is certainly headed that way. And the outside world will probably change so gradually that we should have no particular difficulty in remaining adapted to the average of the surroundings. The mind should improve in each generation. The evolutionary process seems to make this inevitable. The mental standards of man have steadily been raised, and I see no reason why the development should not be equally gratifying in the ages to come. As to the annihilating collision between worlds, this seems quite unlikely. If these writers understood more they probably would not make such bold surmises.

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[1] W. R. Inge in *Science, Religion and Reality*, by various writers, pp. 351–2.

P. What is it that they do not understand?

A. They do not understand, evidently, that the universal mental Cause is maintaining what is an almost perfect energy-equilibrium throughout the pool of the universe. Except for the slight changes brought about by Evolution, a balanced condition obtains in the average within the bounds of the whole, and there is no reason to suppose that it will be abruptly disturbed. Why should this earth-situation be rudely demoralized by a collision between worlds? No, each star has its own definite place. A destructive collision between stars is as unlikely as a mashing contact between two logs each of which is placidly revolving in a slow whirlpool. These planets in their pool cannot alter their average space-relations quickly.

P. I imagine, too, that the stars are becoming hotter rather than cooler.

A. Mental life should become more active as the sluggishness which we describe as cold diminishes. The law of entropy is not true, as I view it. Intense mental life, I should think, might exist in the midst of flames—not mental life in such bodies as we have, but in others equally satisfactory. Let us not worry about this, however, for the temperature of the earth will not thus increase for millions of years; and doubtless we shall be harmonized peacefully and tranquilly with the slow physical changes.

The problem of the distant future does not particularly concern me. I live to-day, and my significance is represented in the amount of mental Evolution which now takes place in me. This, broadly viewed, seems to be my greatest importance. I cheerfully admit that I seem to be more or less accidental. I am one individual of a species which perhaps might never have existed, and which some day may be destroyed. Certainly no one species can continue to exist, for the process of change gives being to a new set of qualities in each generation. The mammoths suffered extinction—why not the entire human type also? Nevertheless, here I am, existing for reasons which I cannot explain, and I do not doubt that the flow of conscious mind-power which momentarily passes through me will continue to exist after it leaves my person. I believe also that the type of mind-power which will appear in later generations will be steadily improved—not that this thought gives me any particular satisfaction.

At any rate, I feel that these pessimistic prophets know too little to express such vigorous predictions. How can they justify the opinion that there will be a cancellation of all that which processes of the past have developed? The mammoths were extinguished, yes, but a genus of higher mental type succeeded to the earth and its food supply. Mental life as a whole *has* progressed consistently. Is it not more reasonable to suppose that the evolutionary process which has brought conscious understanding, feeble though it may be, into living organisms, will continue to produce life-forms with constantly more understanding, more perfect adaptation, and more conscious control? I behold no abrupt nor destructive reversal of processes in times ahead of us. Such ideas seem both unreasonable and unnatural.

P. You have said that the birth-processes make for more perfect adaptation. What is your ground for this conclusion?

A. I have written on this subject at some length in my first book. Since you ask, however, I shall very briefly review this process of "Selective Purification".

In the unicellular body, which is the lowest form of life, when a new generation is formed the parent body itself divides. By this fission, two living organisms appear in place of one. In the higher forms, including mammals, there is a similar division of the germ-plasm within the ovum. By virtue of this subdivision, an evolution of type is produced.

P. How is that?

A. In the case of the one-celled amœba both halves of the divided parent live until the time arrives when there is not enough food for both. Then the mentally superior organism is victorious in the struggle for food, and the inferior is destroyed. In the case of the human family, however, the first struggle for survival takes place within the ovum. Half the germ-plasm material is invariably ejected from the egg and does not live. I think we may assume here, too, that the mentally superior half will be victorious. The two processes are identical in effect. Both result in the life, and probably in the later reproduction, of the mentally superior half of the organism, and in the extinction of the inferior half. There is a slight difference, however, in routine. The halves of the divided protoplasm fight their battle for survival in the world at large, with all comers, whereas in the higher orders, such as man, the first struggle for life takes place at the time of conception; and then, after the physical birth, the growing organism fights another life-battle—this time with shortage in subsistance, and with other members of the species.

This later life-struggle, however, does not stand for Evolution. Superiority has been created before this. The struggle with the environment is merely a sorting process. When oranges are sorted for crating, no new qualities are created, but those oranges which are already large are separated from those which are smaller. The process which makes some oranges large and others small has taken place already in the seed. Real evolution of species, or improvement in mental type, occurs at the time when a new life-form *is being created,* in the production of the seed-organism, and not during its growth in later life. The fundamental quality, that which distinguishes a man from an ape, depends upon the quality of the germ-plasm—and this new quality is created by union and subdivision, and by natural selection at the time the particular organism is formed.

P. I grant you that the earth-environment merely sifts the more perfectly adapted from the inferior, and does not create any new type. I perceive also that the mutation which creates a new type of species must take place at the beginning of each generation, before one particular part of the life-force takes possession of the egg, and not thereafter. Evolution must occur at the very beginning of the formation of a new life-organism; but what is this Evolution, and why does it create a constantly higher mental type?

A. The subdivision of the amœba, and of the chromosomes of the higher orders, this splitting of these quality-factors of the mammals into halves, only one of which eventually lives, is based on a physical principle. Yet, division can occur in accord with only one principle at a time. Thus, if a material body is divided by a physical pressure—as a drop of water is divided by gravitation when it reaches a certain size—its two halves may be almost identical in weight, but the total heat in the two halves may not measure the same. Other characters may vary also. This principle is more easily understood by referring to bodies less uniform in quality than homogeneous drops of water. We may divide with a mechanical wedge a group of forty men into two groups of twenty men, but we do not expect the twenty ablest to be in one group. Nor is it possible that in the average the blonds will thus be separated from the brunets. If we divide the men on the basis of obtaining equal physical weights in the two groups, we cannot expect that the mental weights will be equal in the two groups.

Now the amœba is divided by physical pressure when it reaches a certain size. It divides like a large drop of water. We have every reason to suppose also that the fission by which a new human organism is created, occurs in response to a similar physical pressure. A pressing physical wedge splits the chromatic body into approximately equal halves; and it is quite unlikely that the two halves will possess equal measures of mentality. Not only will the halves be different mentally, but one-half will be superior mentally to the average of the whole before being divided. This *must* be so. It corresponds with the conclusion that when forty men are divided by a wedge into two groups of twenty, one of the two groups of twenty will be abler, in the average, than the other. But, if one group *is* abler than the other, it will *also be abler in the average than the average of the forty men before subdivision.* In this process, then, of growth followed sooner or later by the discarding of the mentally inferior half, we discover a semi-automatic process which will produce a higher and higher mental type of life-organism.

Continued mental Evolution seems most likely, therefore,—perhaps not continuously in man, but somewhere,—and I am not impressed with contentions to the contrary. Some even seem to think that such a superficial matter as the use of automatic machinery in adult life might prevent our natural endowments from becoming ever stronger. Surely nothing in this life on earth, nothing in present man-made environmental influences can prevent the real evolutionary change from taking place before the man appears on earth.

We seem to be sure of this process of mind-intensification. The average density of mind-power in our substance is being increased, so to speak. By virtue of this process of ''Selective Purification'' the average mental quality of the generation of to-day is superior to that of the past. Surely there can be no cessation in fundamental mental growth regardless of our mechanical doings during a unique and doubtless short-lived period of excessive industrialism.

Cycles of unfortunate customs, of wars that kill off our best while young, or of reckless philanthropy that breeds our lowest at the expense of the highest, may, at times, lower our averages temporarily, but Evolution still proceeds. The mental quality of the lowest *must* steadily improve throughout the ages. We must not be so much discouraged by what happens in the depressing parts of the cycles. Waves fall and waves rise. However low a wave may go during one moment, however discouraged we may then be, we must remember that the average of this current steadily mounts.

When we understand the nature of the processes about us, we shall not listen so readily to the pessimistic words of those who see no more than the roll of the billows close by, and who affirm that there is no change in the uniform level, that the waves are as they were yesterday, that these changelessly repeating undulations represent the only significance, that there is no rising toward a higher state, and that the belief in progress is an inane superstition. If there were no human progress there would still be fundamental Evolution; but I believe there is human Evolution, a process of mental becoming in us here on this earth which is steadily improving our quality, and which is making us constantly more able to regulate our lives for our good.

P. Then mental Evolution proceeds within human beings regardless of what takes place during the selective processes of after-life?

A. Yes. The process of evolutionary improvement in species seems inevitable, so long as the species exists. It is even placed so that it is beyond meddling interference.

P. If what you say is true, and if man is becoming constantly a higher and higher type of mental animal, the outlook for his future is promising.

A. It is; but I should feel equally assured of the continuance of fundamental Evolution even if the human family should be exterminated. The Evolution to which I refer particularly is not the unfolding of any one species, but is the process of the transformation of matter in general into spirit in general. It will proceed whatever the fate of one living species may be.

P. I agree that our concern over the fate of our species is sentimental. It should make no difference to us what kind of life will be found playing about on the surface-skin of this little earth-speck some thousand years hence. As Thoreau said: "Man is a past phenomenon to philosophy. The universe is larger than enough for man's abode."

A. Yet, now that we do exist as self-conscious, evolving organisms, we should understand what is going on, and we should properly realize our own possibilities. If we could discover the truth about ourselves we should be able to improve our lives. The more we know the better we can regulate our social state so as to avoid unnecessary pain. On this account the study of ourselves in our relationship with the general scheme is interesting and important.

P. As you have pictured the evolutionary process in man, the vital process which produces a new type occurs before actual consciousness, and takes place, therefore, without conscious suffering. The mentally inferior being is discarded at a time of mental insensibility.

A. Yes, the members of the species suffer—in the processes of life-adaptation.

P. And as to this life-cycle of birth, growth, cessation of growth, old age, and death, it seems to be a remarkable routine. Surely something important must be accomplished by it—otherwise it would not be.

A. Doubtless you are right. Without the life-cycle there would be no generations, and, therefore, no improvements in type. This physical subdivision is essential for the Evolution of the mental quality which the physical imprisons. Because there is such a plan of improving the mental type, one must suppose that the mental Power, directing all, regards the process with favour. The life-cycle seems to signify something more than a chance result. It appears to have been ordained that life-organisms should live on this earth, and should follow a certain routine of expansion and fission in a process which increases the mental purity. I do not believe, therefore, that this mental life is doomed to sudden extinction, and that this accomplishment will be summarily cancelled.

P. Why does the organism always grow larger physically and mentally up to a certain maximum, and then cease growing, and finally begin, physically at least, to disintegrate? This life-cycle in man from youth to old age—what is the cause of it?

A. I shall ask you a question that bears on this: Why does the amœba split into halves when it attains a certain size?

P. These lower forms of life are soft and liquid. The physical formation will not hold together after a certain volume has been reached. It is, as you say, much like a drop of water, although less homogeneous. Hence it is easily disrupted. I suppose that the physical body of an amœba, after it has reached a certain volume, cannot be made larger by additions. Like a drop of water when more and more enlarged, it will flatten out under gravitational pressure, and finally will be subdivided by this mechanical force, and will become two bodies. If the pressure known as gravity should be due to a general mental Power, then the organization of the amœba is submitting itself to this superior Will. The ability of the mental power of the amœba to organize its own body here succumbs, for it has come into conflict with the will of a higher Power.

A. Quite so. And the routine of the amœba applies to human beings. After a certain amount of growing the body can no longer be held together in resistance to physical pressures by the mental principle in charge. Then it disintegrates.

P. I do not regard the analogy as particularly appropriate. The drop of water does not grow old gradually in a physical sense. It does not weaken slowly, and disintregrate a little at a time, but rather it divides suddenly, at a time when it can no longer balance the disrupting pressures. Gravity mashes it flatter and flatter, but it only becomes flatter as it becomes larger. It does not cease growing until it divides—and, in one sense, dies.

A. There is a distinction, as you say, particularly if you are unwilling to admit that water has a directing mind. The resistance of the drop of water to subdivision may, of course, be entirely physical, although I doubt this. Nevertheless, it grows to a maximum size. It does flatten slowly at first, and then more quickly as it becomes larger. Finally it quickly divides. At that time its former unit-organization suddenly ceases to be. The entire body-matter of the parent-drop is contained in the two smaller drops, but the old organization no longer exists. Now I admit of life-forms more complex than the one-celled body, that the whole physical body of the parent organization is not, as in the amœba, used to form the next generations. The parent-organization, moreover, does not enlarge unceasingly up to the time of its death, but dies by degrees. The amœba, a true life-form, follows the principle of the drop of water almost precisely in its regenerative processes; but the more complex species follow a somewhat different routine. Nevertheless, both amœba and mammal follow the same general system of arriving at mental purification. The amœba does not resemble the drop of water in the principle of its growth—but only in its principle of subdivision after steady enlargement to a maximum size.

P. How does the growth of the amœba differ from that of the drop of water?

A. The accretions which make the amœba grow are acquired with the aid of the amœba's mental power, and are partly selected by its mental judgment. The enlargement of the drop of water seems to depend upon the chance that other water-particles may come into contact with it. Nor can it protect itself from evaporation. The drop of water does not go in search of sustenance, and it does not alter the substances with which it comes into contact so as to draw water-molecules from them. Water seems to be almost entirely inorganic rather than appreciably organic. It is physical far more than mental.

P. But still I do not understand why the bodies of the more complex organisms grow for a certain period, then cease growing, then lessen in vitality, and then die.

A. The process seems to be something like this: First there is a union of germ-plasms in the egg. For some physical reason, perhaps, the whole of the germ-plasm (in man the 95 or 96 chromosomes of the two sexes) cannot remain in the egg. It must divide like the too much enlarged drop of water, and then, after a test of mental superiority, the inferior half is ejected and the superior half remains in possession. The victorious mental power in the egg (or seed) now organizes for itself an appropriate body by making use of the substance of the egg which has been so carefully selected by the mother. The new life-form grows until the the egg-material is largely consumed. The offspring is then hatched, or born, and is then able, with or without the care of the parents, to make its way in the world outside. It then searches out and selects the food appropriate for further body-building, and it grows larger and more vital.

As this complex organism grows, there is a constant increase of that choice body-substance (whatever it may be) from which the mental forces are generated. For the sake of illustration, let us suppose that all this selected substance is stored in one central reservoir, or drop. This is the germ-plasm material.

As the body grows, the central drop-formation becomes constantly larger, and the parent-organization becomes constantly more vital and virile. The body becomes larger and stronger physically and mentally.

This process of enlargement continues until the magic age of puberty.

P. What happens at puberty?

A. At puberty the central drop apparently reaches its maximum size. After that, the increments cannot be retained in the central reservoir, and are sloughed off to become separate drops. For this reason man attains his maximum physical and mental stature at approximately the age of fifteen. After this, the mind acquires more of the knowledge due to experience, but it does not increase appreciably in its ability to do original thinking about matters wherein experience adds nothing to judgment. For a short time after puberty the body strengthens physically, but all growth soon comes to an end—and then a retrogression sets in.

P. But why this retrogression?

A. There is one principle which Nature seemed to follow consistently—she does not waste energy. When the central drop has reached its maximum size, and when a place has been arranged (as necessary) for the deposit of the excess material, there will be two places of possible deposit. To which, do you suppose, may new material more easily be added?

P. To the smaller supply, of course. This principle may be demonstrated in physics.

A. Here, then, is the crisis in the life of the parent. At the time that it becomes necessary to deposit the vital material somewhere else other than in the central reservoir, the life of the parent has risen to its highest—the wave of life has reached its crest, and is about to subside. Not only will the parent then cease to grow, but it will begin to lose ground. From this time forward the vital material will be stored, not in the central drop, but in the places of smaller deposit. Here it will go because this is the easiest way. The vital forces of the adult in the central reservoir, consumed as they are in the life-experiences, will not be replenished.

Here is a battle for life between the parent-organization and its offshots. In this contest the parent body is doomed to lose. Otherwise the future would hold no opportunities of progress, for, if there were no generation of a new form, there would be stagnant, unadapted sameness of kind. The potential offspring, the higher type to be, invariably wins in this contest. Nature's forces support the routine which leads to progressive change. The children in embryo, by absorbing the vital forces otherwise coming to and stimulating their parents—that is to say, by winning this battle for the vital forces of life—kill their parents. Every death from old age is a proof of this victory. Each succeeding generation slays the preceding, although the killing process is unnoted and unwilled consciously by the killers or the killed. There is no escape, no compromise here unless the mental power of man himself intervenes to re-order the situation. A mechanical force-principle is asserting itself with unfailing power—the principle that matter in motion will move over that path which offers the least mechanical resistance. This process is spiritually divine, because the force-principle which causes it is spiritually founded.

Likewise a river, when once it overflows its dyke, when the first trickle ruts the top of the soft bank, has then reached its maximum expressiveness. Except for outside intervention the river thenceforward is doomed to shrinkage. The overflow cuts itself an easy channel through the mud. The excess is not content to flow over the bank, leaving the old stream as before, as it might, but, instead, drains the stream lower and lower. The channel through the dyke becomes easier and larger hour by hour. More and more as the days pass the parent river will be drained of its flow, and the final result may readily be predicted. The time will soon come when the old river-bed is a dry waste, and when the force of the old current, with a new personality, traverses a new channel. The life of the river is destroyed by the principle of the overflow. The current gradually abandons the old course altogether, and a new stream is created at the expense of the old. The path of least physical resistance has been followed.

The new stream, however, will not live forever within the banks between which it flows onward. The swelling current will finally overtop them, and the water will again change its channel. Another personality will have been sacrificed to create a higher type.

P. If this theory is sound it is fortunate that Nature has thus arranged her process of improvement. An external test of fitness between parents and their children, all striving for the limited amount of subsistence, would be painful indeed. I do not see how we could stand the horror of it. The amœba endures this horror; but probably it does not realize.

Yet I see clearly that the battle *must* be fought. Otherwise there would be no extermination of the aged. If the parents lived on indefinitely, while births continued, population would quickly increase to the point of starvation. There is an increase now, and a struggle to the death between the too numerous. This I perceive, but this struggle does not take place openly between parent and child. Nature has hid her parricide where it proceeds mostly unrealized, decently, and almost painlessly. The adults, as you say, are quietly eliminated by a process of starvation as regards their vital forces. They die because the life-force is diverted from their personalities to that of their seeds. In many species the mother dies at the time the first offspring is born; and parents never last very long.

A. Yes, the unrefreshed body of the adult shrivels and becomes constantly less vital. The face wrinkles, the hair falls out, the teeth decay, the bones become brittle and the arteries hard. Soon the body is unable to produce seed-secretions.[1] Yet it may still linger for a few years, impotent in some ways, but able to absorb nourishment, to hobble about and take care of its young. Indeed, this old age would probably not be vouchsafed except that the young require this period of care.

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[1] It is quite possible that life might be prolonged by some process by which

Finally the physical body disintegrates in some essential particular. There is no longer a stream flowing along the old channel; there is not even a continuous body of water, but merely a series of disconnected pools drying in the sun. At this similar stage of the man's life, he ceases to function as a unit-organism; and his withered flesh is buried under the ground where the chemical parts may continue to decompose—finally to join the inorganic dust.

P. The amœba, however, seems to possess a potential immortality of body. Both halves live.

A. Yes, but this immortality is theoretical rather than practical. There is insufficient room, as I have said, for a perpetual multiplication of the species, so the superior takes the food from the inferior and kills it.

P. To return to your theory of the life-cycle, your explanation of it seems fairly reasonable, but what causes the union of sexes? What is the explanation of sex-attraction?

A. At least we can say that it springs from a mental urge. Apparently the urge harmonizes with the mentally ordained plan of Evolution. Apparently the sexual impulses originate in subconscious mental emotions, which, in the higher types, at least, reach partly into consciousness.

P. With more consciousness of himself, with more reasoned control, man could doubtless reduce his suffering. He might even solve the problem of over-population. The painful life-selection may finally be dispensed with.

A. I agree that if mental powers were sufficiently exalted every type of unbalanced strain might be appropriately compensated. Nor do I believe that Nature intends

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the proper amount of these seed-secretions could be restored to the parent-organism from time to time as needed for the maximum vitality.

that man shall go through life forever with his body starved and tormented by disease, and with his nervous system battered and abused to a point of mental desperation. Nature intends that conscious minds should improve; and the evolutionary system guarantees this result. Human beings, or their successors, will eventually be highly endowed with conscious wisdom. At that time they will wither quietly in the autumn of life, and die peacefully and painlessly. And they will consciously and joyfully sacrifice themselves to their children. They will end their lives much as do the dead leaves, which, without pain are snapped loose from their brittle stems by the least gust of air—and then quietly drift down to earth.

P. The unhappiness of man to-day is largely due, then, to his inability to control his environment?

A. Evidently. He is quite unconscious of the exceptional. His dull mind requires a repeated experience to be impressed. Chiefly the rut of habit is followed. Grooved channels of conduct—and the brutal pains which record all deviations therefrom—guide him in most of his doings. So uncomprehending is he of the exceptional or unfavourable that he often submits himself unwittingly to an environment in which he will wilt like a flower in the hot sunshine. Thus the American is now subjected to a particularly abnormal environment. His white skin is unsuited to the actinic rays of the dazzling American sunlight. He suffers like the orchid in the sun. These swift particles, uncurtained by fogs, penetrate deep into him, and shatter his nerves, yet he does not understand why he is so restless, nervous, and excitable. The pioneers came to America in droves, reckless, little understanding; and now their descendants wonder why they suffer as they do. An exaggeration of this lack of physical adaptation to the sunlight would destroy the American utterly—as it has destroyed the potential lives of English children in India.

The plants and the lower types of animals seem to lead happier existences than poor, semi-conscious, unbalanced, restless, striving, bored man. The lower orders of life are taken care of by instincts. They do not feel the pains of the life-struggle keenly, if at all, hence their days pass fairly peacefully.

Yet they have no conscious happiness, and we incline to regard a lack of conscious understanding as the same thing as non-existence. Here is man, superior in understanding to the plants, but in a transition state, and to-day we may well question with Schopenhauer whether pain or pleasure is in excess. Personally, however, I prefer to live consciously even though the consciousness brings more pain than happiness. We cannot bear the idea of living without conscious appreciations.

P. But I understand that you are convinced that the day will come when man's free-will—that is to say, his conscious mental direction of himself as regards his environment—will be so exalted that he can attain a comparatively peaceful existence?

A. Yes, the life-span of man eventually should be passed in comparative happiness, and come to a quietly normal end. Even though the body withers, its bodily relations should remain constantly in inter-harmony. Within such harmony, whatever the intensity of life, there should be no pain. Man should die when all his functions together quietly cease—that is to say, when life simply is no more.

P. Such a life, as compared with that of to-day, would represent progress. If it is a reasonable expectation it should make us meliorists.

A. I am not a pessimist. I am merely trying to see facts as they are. To take the most important step towards this goal of a better life we must appreciate our own place in the scheme of things, and particularly our relationships with the physical forces—those motions which are mentally driven, after all. We must not rush rashly into sure tribulations. We must not migrate to India if we desire grandchildren. We must partly conform ourselves to Nature, and not attempt too much to regulate her. We must not set up unruly waves of physical forces. We should temper the oscillations rather than arouse them. And, above all, we must subscribe to the principle of Evolution. When we have submitted ourselves to the dictates of this plan, when we have arranged our life-procedure harmoniously therewith, and when we have moderated those physical wave-cycles which are now subject to our reasonable control, we shall have journeyed far along the road to happiness.

P. After hearing you talk about the inaccuracies in classical scientific opinion, and about the possibility of introducing a spiritual Cause as an explanation of all phenomena, it came into my mind that among the more important questions were these: How do we acquire knowledge, and how do we know when we have reached the truth? Can we ever know anything exactly? Do we learn only through experience, and, if so, is our experience ever exact? Yet, do we learn only through experience? And, if so, how? Isn't experience a strange meeting of mind and matter? How can it ever reveal exact or inclusive truth? Does it relate to all the universe, or only to the orderly part of it? It seems to me that before one wrote a book introducing new theories he should first wish to ascertain whether it is possible to know anything exactly—and whether it is possible for our knowledge to refer to (and, therefore, formulate) more than the orderly and composite relations.

A. What you say is sound. Certainly it is logical that before one expresses ideas he should first demonstrate, if he can, what knowledge is, its limitations, its necessary type—if limited, how it can be acquired, and then how it can be proved true. This should be the first procedure of the philosopher, and, to be sure, the nature of knowledge has been one of the chief subjects of philosophic discussions since the earliest days of recorded thought. In this book I have stated in rather general terms my view as to how knowledge of the phenomenal world is obtained, but I intend, nevertheless, to take up this subject in greater detail. I have already started my next work.

But my dear sir, I have already taken up more of your time than I intended. Good-day. I enjoyed the conversation.

CHAPTER XXXII

UPON CLOSING AN UNEMOTIONAL VOLUME

Blindly and bloodily we drift,
Our interests clog our hearts with dreams.
God make my brooding soul a rift
Through which a meaning gleams.

MASEFIELD.

LIFE appears in us, partly knowing itself, realizing somewhat its problems, its devious ways, its dim present, its dimmer future, its facts and uncertainties. The world is a mystery, the heaven an unknown. Faith is our chief reliance—but faith is weak, limited to itself, and only slightly sustained by reason. Alas, philosophy has failed us! We have not received the expected consolations.

Our mental life flickers but feebly; yet we can see in its flame and shadow that we live—shortly to die. We cannot distinguish precisely between the living and the dead, between a man and a stone, yet we believe in a degree of difference. Nevertheless, we are fleeting ghosts of this earth; and the mystery of the future is so impenetrable that we are afraid. We know not where we go, or whether we go.

We alone of all the different living forms, even in health, tremble consciously as we anticipate earthly extinction. In the words of Amiel, "the imagination shrinks in fear from the phantoms which it creates." Or, as Shakespeare makes Cassius say:

". . . he that cuts twenty years of life
Cuts off so many years of fearing death."

We dread most in those hours when we let ourselves think. Then we need our strongest faith, our most reassuring tradition, our thickest shield. We seek diversions so we may not ponder. Let Maia be our comfort in these gloomy hours; let illusion hide the truth from us; or let gross stupidity deaden us—we care not which. Faith, to-day, is not confirmed by thought; but either faith, supported perhaps by some hidden intuition, must rescue us, or some opiate of dullness must deaden us, or occupation divert us. Otherwise we cannot endure.

To be able to think, and yet to think no better—this is our thorn and our distinction. Without thought, without consciousness of our life here, and of the death that takes us we know not whither, without a reasoning intelligence capable of realized judgments, without these gifts of analysis and perception—clumsy and weak though they are—without this partial appreciation of what our fate is likely to be, we would be freed from torments of doubt and from bitter moments of dread.

Meanwhile the unknown meanings of life oppress harshly those of the keenest appreciation. Knowledge of life's inner reality is lacking, but these more thoughtful ones observe and chart. Alas, however, the charts reveal only statistics! And so these higher conscious thoughts, too low to accomplish; this struggling logic, too weak to conclude; these statistics, physical rather than spiritual, afford pain rather than joy. Nothing avails, nothing seems worth while to the more thoughtful ones; and melancholy eats into their souls as they daily contemplate their futile routine. They behold no proud accomplishment in one generation, and no certain progress in many. And, if their thoughts wander to the time after this earthly life, what is discoverable there? Nirvana, perhaps? Annihilation?

Desperately does man struggle to enjoy his living hours. Vigorously does he strive to escape physical wants and diseases, and the mental horrors of tedium and fear. But he is strangely paradoxical. Although in pain, both mental and physical, although bored and suffering, he nevertheless cherishes his earth, and, a miser of Time, clings to each of his fleeting days. Though he professes belief in a paradise beyond, he holds anxiously to his flesh, his only certainty—

afraid to die. Contemplating the physical as perhaps the final end, he shudders at the thought of perpetual non-existence. He can think back to the time before existence without dread, but not to the unknown hereafter. Fantastic, pathetic, man! He values the present which is known to be painful, and dreads the state after life which he believes surely to be without suffering. Yet, this, after all, is not a paradox. It stands rather for a great reality. We perceive here the mental being clinging to itself, clinging to its own, regardless of consequences.

Time, painful as it may be to us, is regarded as our most precious possession. The jewel, so prized for its glitter of cold hardness, is the proper symbol of the days which we spend so joylessly, and which are penetrated by so little significance. Only a few, relatively, receive a satisfying consolation from religion; and too many of these, with their strong faith in a personal immortality, have built unstably high on the superstitions taught them by priest or parent. They dream of a future which they desire rather than discern. It is difficult for Reason to follow these footsteps.

Day after day men repeat the question: What accomplishment, what deep meaning does this earthly life possess? When we seek for accomplishment and meaning, what is found? Nothing but the perpetuation of our kind! The species lives on and on. We are links of a great chain of life. Does not this chain perhaps attach to some far-away goal, then, and except for us, might not its ends fall dismally to the ground? By means of us, the past of our species connects with the future. The past emerges from the dust. To what, then, does the future attach? And is it a high aim? To be a link in the chain of life is no accomplishment—unless perhaps the life accomplishes something by continuing. If no value rests in us now, is there anything to be gained by prolonging our kind even to eternity? If our beings of today, when summed, are found equal to zero, then our perpetuation is no accomplishment!

Another principle must be considered. Only naught can grow from naught. No evolutionary scheme can produce something from nothing. If man now takes no part in a divine scheme of becoming, or if, to-day, he is no more than zero, then the future man will play no important part. If man is to trust his future he must discover and identify value in his present. Man does not see ahead, however, hence he must either accept his religion on faith, on blind desire, on the hidden knowledge unknown to consciousness; or else he must, with his reasoning mind, prove his present-day value, his reality, and therefore his claims to significance and immortality.

This last, indeed, is the province of thought, the proper aim of philosophy. But, alas, frail philosophy has faltered. Her tender strength has been too little to speed the arrow to its mark. In this dilemma what must poor illogical man do?

Until philosophy demonstrates, until reason conquers, man must, if he is to have consolations, rely, not upon what he knows, but upon that which he intuitively feels. In this stage, only part way towards conscious understanding, man must base his hope and faith as best he can. Indications must be accepted as they appear to him, whether growing from reason or unreason, whether from his conscious or subconscious mind. Then, as Evolution proceeds, the man who lives some future day, with understanding perfected, with philosophy triumphant, will permit no doubts, will have no forebodings.

Is conscious understanding in man close at hand, then? Is fear soon to be dismissed from us by philosophy triumphant? Is mental Evolution progressing rapidly within us —and now about to reach the desired goal? Is a spiral of change almost at its end in which unconsciousness is to become completely conscious; in which intuition will be replaced by reasoned thought; in which vague fears are to be banished by happy certainties; in which a mentally driven ethics will take the place of physical injustices; in which sin, fear, and pain will be cancelled from earthly life?

Yes, we *are* approaching that time when our days will be praised rather than criticised; when pleasure will be a ton and unhappiness an ounce; when, goodness abounding and sin unknown, we shall unite in exalting the principle that created us. It is our grief to-day merely that we pass through a necessary period of developing change, and that we look at ourselves in that transient phase when philosophy is weak and fear strong, when we are neither man full-grown nor plant unfeeling, when we still require physical pains to guide us, and when, still essentially materialistic, we are gifted too little with the power of thought. In this stage of our transition, we misjudge a phase for a perpetuity; and our inadequate minds torture us with their vague beliefs and unbeliefs. This is now our heavy burden. What, then, is our hope that it will soon be lifted? When shall we gain that higher and happier state of mental freedom?

If we had no conscious understanding, we should now escape this mental anguish, but we should then perpetually sleep. We should be more like plants or stones. Surely there must be another way to escape! Surely the alternative for pain will not forever be torpor. Surely there is some purpose in the very being of consciousness—some quality more meaningful for thought than its ability to suffer through its physical associations. Surely a path to happiness is to be vouchsafed us through the very heart of mentality. Although our eyes are blindfolded, the light is now softly sifting through. Soon we shall be able to see through what now appears as a blank wall of darkness.

All this I believe; yet life now gives a different impression. If we look about or within, we are not encouraged. The average everywhere tends to depress and humble our expectations. Even the highest of our species arouses no special admiration. To-day the activities of man are concerned chiefly with self-preservation. Vanity, selfishness, self-gratification impel him. Few achieve unselfishly or create impersonally. Few have imagination, artistry, noble impulses. We think but little, and, in general, live unbeautiful lives. Boredom treads closely on our heels. We may escape ennui, but the escape is but a negative blessing. Our feeling of happiness comes principally from proofs of superiority. We laugh when we feel exalted, or when others seem humiliated. Few of our doings spring from high ideals or from admirable principles.

We pass our days in self-deception. We fail to make the easy self-analysis; we pin badges of virtue to our gowns which we know are deceptive shams—tinsels without real worth. We draw a veil of illusion about our lives, in front of our minds. We deliberately shut out the real. We pass our days with eyes purposely covered against the unpleasant, with ears muffled to sounds we would not hear. We go about swathed in make-believe; and the curtain usually drops on a part bravely acted, with tinsel still worn as if a robe of honor, and with a more miserable fate softened somewhat by our own acts, by our own use of will.

Yet just here must we pause, for a great reality reveals itself, its greatness perhaps justifying not only our acting, but our lives and ourselves. We *do* temper fate; we *do* partly alter the throw of chance; we *do* somewhat control the fall of the physical dice. It is this freedom, weak as it is, which particularly distinguishes man—which proves that his life, and all life, is dualistic, and, therefore, more than a physical zero. It is this fate-directing attribute of man which must be interpreted properly by philosophers. It alone lifts him above the mud, and makes him feel that he was not made merely to die. Nor can this unphysical power be interpreted by these mathematicians and physicists who now describe cold science to us.

> ''Men at some time are masters of their fates;
> The fault, dear Brutus, is not in our stars,
> But in ourselves, that we are underlings.''

But as life now is, as men now are, the more animalistic, more physical person—the duller, cruder, grosser man—better succeeds in passing his days without undue trepidations and mental anguishes. His lack of imagination, his larger failure to realize himself, permits him somewhat to escape. He does not need so much make-believe. He has less to forget, less to veil. Being less acute he is perhaps less egotistical; but he is more deadened, more commonplace, more inartistic and insensitive. Indeed, he is quite different from those persons who are tender, shrinking, and gentle, who are tense, imaginative, and creative. These more highly organized beings seem to realize themselves *too thoroughly.* Being more intelligent, more conscious, they are more moved by fears. They are not stones, nor clods, unfortunate ones, yet their minds are too weak to understand or protect. They are in the miserable half-way stage lying between the protection of insensibility and the capable direction of conscious understanding. They tremble with apprehensions, many of which are justified; and they shudder with morbid anticipations, many unjustified. Life to these is often a nightmare. A pessimism is theirs which the more stupid person avoids. Which state, then, is higher?

Indeed, these delicately attuned, introspective, morbid souls often contemplate suicide. James Russell Lowell believed that every realizing man, at some time in his life, thought seriously of self-destruction. Thus it was with Tolstoi, Keats, Mohammed, Nietzsche, Cowper, Rousseau, with William James and Goethe in their youth, with Lowell himself, and with thousands more.

Regardless of its pangs, the higher mental state is higher. The sensitiveness which at times shrinks from its imaginings has its compensations, and more! Nature at times shines on these emotional beings with surpassing loveliness, with stimulating beauty, with a glow of hidden meaning. Their tuned-in strings of ear and mind and eye vibrate then in harmony with the rhythms of the universe, and they are transfigured. They escape then from their bodies, and leave the earth behind. They harmonize then with the intangible Infinite behind the physical veil. Their freedom consists of more than paltry regulations of the physical. They live in the mental. At such times life signifies to them, not illusion, not futility, but completion and certainty. They feel that their souls are closely bound to the divine in nature, to the Spirit which fills the stars with fire, and which urges the planets. They recognize this sublime harmony as Beauty, and this Beauty their arts proclaim. Beauty, as the poets sing it, as the composers blend it into music, as the artist places it on thin canvas, as the sculptor carves it from marble, is revealed to a tingling, subtle, almost unrealized but vivid intuition, as the Divine Principle behind action. They view here something still uncharted, unformulated, non-material, indescribable, and still mostly outside scientific truths. Thus the poet Masefield sings of "Beauty that is more wisdom than the wise."

These purposeful force-movements in Nature meaning Beauty, these rainbow colour-blendings of the waterfall; these sound-harmonies to which our joyous moods respond; these soothing warmths of sunshine; these delights of light and shade, of curves and forms; these springtime burstings into life of plants and trees; these views of mountains, peaks, and chasms, expressing deeply the sublime Creative Power above; —all these and other symbols stand for our artistic ones as something vividly real, something supremely worshipful, as even the token of a transcendent Becoming of the World and of us. The sensing of it alone marks the mind for immortality. Feeling all this, these artists glorify, and believe.

Yes, they can express in part, these sensitively endowed ones, but, alas, they cannot explain. They are enraptured, but they cannot reason. They know, but they cannot exactly tell. Emotion, not logic, possesses them. Mysterious intangibles alone bear them witness. They pursue something overreaching knowledge,—something, indeed, which the unrolling of Time will bring before them and make of them. There are no formulas here—merely vague revelations. This sensing of a Divine principle in the harmonies of Nature about; this stammering description from the subconscious of that which the conscious cannot grasp; this emotional glimpse of an accomplishing Principle which surpasses the highest intellectual understanding, now presents our greatest reality. Art to-day leaves science trailing. Emotion to-day is more right than reason; for reason is weak, easily deceived, and often astray. We cannot define electricity, or matter, or gravitation perhaps, but within the physical movements we can sense more of the basically real than we can define. An aroma of meaning spreads unseen which tells us more than these hard mechanical laws reveal. Our sensitive ones prove this to us by their lives and arts. All hail, then to our artists!

The tensely organized person has his full compensation in those moments when his instincts rule him, when he is in accord with these inner symbols. Then, he envies no longer the dull clod to whom these higher meanings are meaningless. No longer does he credit the claims of the mechanically scientific and coldly analytic. He is now sufficient to himself —and his art expresses his feelings partly. Let us turn in proof to the words of the artist in his happy mood:—

> The green carpet of the plain is dappled by the passing shadows thrown upon it by the clouds; the landscape has the charm of the delicate tint and a sort of languid grace. Already I am full of a sense of well-being. I am tasting the joys of that contemplative state in which the soul, issuing from itself, becomes as it were the soul of a country or landscape, and feels within it a multitude of lives. Here is no more resistance, negation, blame; everything is affirmative; I feel myself in harmony with nature and with surroundings of which I seem to myself the expression. The heart opens to the immensity of things. This is what I love!

This was written by Amiel on Mount Salève in April, 1868. Almost a year later, when exhilarated by the sound of beautiful music, he wrote more intensely:—

> Such impressions are the echoes of Paradise in the soul; memories of ideal spheres whose sad sweetness ravishes and intoxicates the heart. Oh Plato! Oh Pythagoras! ages ago you heard these harmonies,—surprised these moments of inward ecstasy,—knew these divine transports! If music thus carries us to heaven, it is because music is harmony, harmony is perfection, perfection is our dream, and our dream is heaven.

The happy mood soon passes, for Amiel is middle-aged, and the youthful enthusiasms in him are tempered. He is often sceptical of his own intuitions, of that which his instinct proclaims. The mists gather, the fires of life burn low, and nature and sensitive man often reach despondent depths. Reason incomplete and perplexed, philosophy sceptical, uncertainty making headway, no logical assurances anywhere, this melancholy Genevese Professor suffers a devestating gloom. Occasionally he surrenders everything. In July, 1870, he wrote in his *Journal Intime*:—

> What is man—this weed which a sunbeam withers? What is our life in the infinite abyss? I feel a sort of sacred terror, not only for myself, but for my race, for all that is mortal. Like Buddha, I feel the great wheel turning,—the wheel of universal illusion,—and the dumb stupor which enwraps me is full of anguish. Isis lifts the corner of her veil, and he who perceives the great mystery beneath is struck with giddiness. I can scarcely breathe. It seems to me that I am hanging by a thread above the fathomless abyss of destiny. Is this the Infinite face to face, and Intuition of the last great death?

It is this hope, this doubt, this questioning of the spirit that concerns us. No great mind has failed to have these varying moods—first this assurance of a meaning in life, and then the despair of it. And often the moods become strangely mixed. Thus we find Amiel saying:

> All life is the shadow of a smokewreath, a gesture in the empty air, a hieroglyph traced for an instant in the sand, and effaced a moment afterwards by a breath of wind, an air-bubble expanding and vanishing on the surface of a great river of being—an appearance, a vanity, a nothing. But this nothing is, however, the symbol of the universal being, and this passing bubble is the epitome of the history of the world.

Our life is now restricted, hidden in this haze of stupidity; but the haze seems to be lifting. Occasional glimpses of brighter, broader realms prove this to us. We shall not forever swing with happiness on a wave of vivid beauty given us out of hidden springs, only later to fall deep into the dusty hollow of uncertainty. We shall not always glow one moment with rising hope, as force-harmonies make themselves felt within us, making us thrill we know not why, only to collapse in despair as ugliness and futility bear quickly down upon us, and as our minds question even the beauty and harmony. We are mental beings, remarkable above all other life-forms for our ability to think and reason consciously; hence we shall not forever rely upon mere instinct or mood for our greatest truths. We shall not always argue that an infinite purpose is displayed in the motions of matter merely because we delight—we know not why—in some colour-or-sound-movements, or in successions of rhythms which entrance us.

These misty senses of beauty, and these unexplained appreciations of harmony, are not to be forever our only logic, our only knowledge, our only faith, our only basis of religion. Although we may to-day accept these revelations of intuition as dependable guides; although to-day our inner feelings are wiser than our mechanistic sciences; although, with our emotion as our assurance, we may deny the doctrine of mechanical necessity; yet, we need not always assert our cause so timidly and tentatively. The mind of man will soon step boldly forth and claim its kinship with the Divine. It will soon mark its relationship, assert its immortality, prove its own greatness of being, and claim here, even on this whirling ball of earth, its right to joy. It will banish pains, injustices, and fears into the limbo of darkness. A dazzling mental light is to illumine our earthly lives.

The Conservationists, the Materialists, the Mechanists deny that there is an active overruling mental Cause, and that the Evolution of matter into mind is real. They deny this transmutation by a heavenly alchemy. Thus, virtually, they deny man a code of ethics, a means of knowledge, a basis of morality, a principle of ''absolute'' action, an accomplishment that might be mentally driven. The heavy weight of mechanical determinism, with its indirect denial of an anywise participating God, has long burdened us with its sour dullness. For centuries it has lain heavily upon our emotional lives. Man is now ready to discard this mechanical basis of philosophy, this concept founded, not upon reason, but upon experiences which are provably incomplete. Reason is now fortified to reject the negation of religion by that which is really a pseudo-knowledge. The mind is now ready to prove its own emotional creeds, its own connection with the real. Religion and reason are now moving towards each other prepared to join hands in a union so true and well founded that surely our dark sorrows will be dissipated by this torch of mental light. Man is gradually becoming fit to step closer to the throne of his Divinity there to receive his consolations. On this earth the reason of man is beginning to proclaim its kinship with the sublime, and, day by day, is better prepared to recognize its privileges, and to experience its rightful joys.

In the beginning—that beginning at least with which we are concerned—matter was much, and the mind associated with matter scarcely any driving force. There was in matter much of inertia, little of motion,—mostly coldness, sluggishness, and darkness. There was little pain and evil, however, for almost all was dead. Later, because of the Evolution taking place in Time, there was somewhat less of matter, and more of mental warmth and light in the substance which remained. Minds possessing a dim consciousness appeared in some of the earthly bodies. These living bodies had much of subconscious feelings and powers in this period, and little of understanding. Much later, consciousness, guided by pain, came more and more to possess them. Then they perceived much of evil to decry, and little of happiness to adore.

This period is still about us, but it is reaching its end. For Life and Matter are still in Evolution.

Just now, indeed, a critical change is being manifested. Substance, giving way ever so slightly, is permitting a new mental presentation. The separation between darkness and light comes to a stage when the partition is of immeasurable thickness, and the slightest movement at this critical time causes the equivalent of a transformation. With the slightest portion of heat added, the dense water of life becomes an invisible steam. Thus it is now with man. His duller, cruder subconsciousness is being transformed into penetrating, knowing consciousness. Soon, as we near the Ending of the Evolution of matter into spirit,—a process which once began for reasons which man as man will never know,—our lives on earth will be all mental warmth, purposeful motion, conscious control, ordained serenity. Then we shall live with happiness, justice, and joy. Soon reasoned understanding, assured convictions, and unalloyed happiness will abound. For all this, we must wait just a little longer after the beginning—after the remote beginning of the dualistic world of inert matter and mental freedom. This, indeed, is a faith that all may share.

For man's faith is soon to be grounded firmly upon perceptions and conceptions—upon more than intuitions. He will attain an intellectual confirmation. There shall be revealed to him ever and ever more clearly and positively the creative, planning Power, the God of Aristotle, the thoughtful, purposeful, accomplishing God, the dynamic Cause, the Transformer of sluggish resisting matter.

The Evolution of substance into spirit,—this Change which because it lies within Time permits Time a measure of importance,—is the great reality. In it there arises that intimate association of mind with matter from which comes man's real, but now confused, knowledge. In the heart of this process man receives both his sense-perceptions and his limited ability to ''know''. Active, tingling spirit is created in him, and thus he finds himself mentally alive. And he, even now, dimly realizes what is being created in him, and the nature of that from which it springs. Valid knowledge thus reaches him, though yet gradually and incompletely, as if mistily veiled, and this dim understanding permits him somewhat to harmonize successfully his life with the changing surroundings.

The appreciation, growing ever keener, of the source, nature, and meaning of this his well-founded knowledge should, at last, give him a sustaining conviction. Created, as he is, by a divine power, and now vitalized partly with the divine quality, man possesses even to-day the germ of a finer understanding. And this means of knowing, when but slightly more clarified, with but a few more of the deceptive illusions of the senses dissipated, with but a little further blossoming and unfolding, will supply the firm bases of an intellectually sustained religion. Man will then, at the very time that he logically denies pure mechanism, place his unbounded trust in a creative Cause declared by reason. In this final ending, religion, science, and philosophy will unite. At the same time man will find that the shining road to happiness has been revealed and charted to him. He need but enter.

THE END

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